UPDATED PHASE I SITE CHARACTERIZATION SUMMARY REPORT

Siltronic Corporation Property
7200 NW Front Avenue
Portland, Oregon

July 22, 2005

Project No. 5237

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SUMMARY REPORT

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Prepared for:

NW Natural
Portland, Oregon

Prepared by:

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Portland, Oregon

HAI Project No. 5237

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1.0 EXECUTIVE SUMMARY

This report presents the findings of investigatory work conducted at the Siltronic site through 2004, including updates to the conceptual site model, in order to support a source control evaluation with regard to manufactured gas plant (MGP)-related contaminant migration from the Siltronic property to the Willamette River.

Research related to historical waste management and site filling activities, in conjunction with data collected and evaluated as part of this study, identified various contaminants of interest (COIs) and sources for those COIs at the Siltronic property. A summary of the main findings of this evaluation are provided below.

1.1 Contaminant Sources Attributable to MGP-Related Waste Management

Portland Gas & Coke (PG&C) operated an oil MGP on the Gasco property, north of Siltronic, from 1912 until 1956. PG&C owned a portion of the Siltronic property from 1939 until 1962, during which time waste management activities were conducted at three portions of the present-day Siltronic property, as follows:

Former 400-foot Wide Lowland Area: Immediately south of the common Siltronic/Gasco property line. This approximate 10-acre area received tar and tar/oil/water emulsifications from effluent pond overflow and from direct placement of MGP residuals between 1941 and 1956. Soil and groundwater impacts attributable to this feature are present at the Siltronic site. Estimates based on tar thickness measurements made in 1960 (2 to 6 feet of tar across much of the area) indicate approximately 40,000 cubic yards of tarry materials may have been present in this area subsequent to cessation of all MGP-related activities at the Gasco site, which occurred in 1956. It appears that materials were directed to this lowland area to minimize effluent discharges to the Willamette River. Contaminants of interest (COIs) related to this area include polynuclear aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs), and monoaromatic hydrocarbons (e.g., benzene).

Former Depression or Excavation**:** South of the former lowland area, approximately 2 to 3 feet of tar was identified at the base of this approximate 0.5-acre apparent excavation when evaluated in 1960. This feature was first observed in aerial photographs dated 1955. Estimates based on tar thickness measurements made in 1960 indicate approximately 2,000 cubic yards of tarry materials may have been present in this area subsequent to cessation of all MGP-related activities at the Gasco site. The function of this depression / excavation is unknown. COIs related to this area include PAHs, SVOCs, and monoaromatic hydrocarbons.

Former Spent Oxide / Gas Purifier Waste Storage Pile: Company records indicate an estimated 34,000 cubic yard stockpile of spent oxide / gas purification wastes were formerly stored immediately south of the common Siltronic/Gasco property line near the western corner of the Siltronic property. Aerial photographs indicate the stockpile was present at this location between 1952 and 1966, several years after NW Natural sold the property. The final disposition of this material is unknown. COIs related to these materials include cyanide and metals (arsenic, chromium, copper, lead, nickel, zinc).

1.2 Other Contaminant Sources

Olympic Pipeline Petroleum Release(s): The Olympic Pipeline utilizes two product lines (diesel and kerosene; gasoline) within a utility corridor that traverses the central portion of the Siltronic property. Line failure resulting in product release and soil and groundwater impacts was identified near the western corner of the Siltronic facility in 1979, proximate to the 400-foot wide former lowland area. COIs related to this area include PAHs and monoaromatic hydrocarbons.

Western Transportation Petroleum Release(s): Western Transportation operated a petroleum fueling dock at the eastern corner of the Siltronic property between approximately 1930 and 1950. Possible surface staining was noted on a 1970 aerial photograph, and petroleum impacts to soil, likely attributable to these activities, have been identified. COIs related to this area include PAHs and monoaromatic hydrocarbons.

Siltronic-Related Releases: Trichloroethene (TCE) leaked from an underground storage tank system operated by Siltronic at the northern portion of the property resulting in soil and groundwater impacts. Related COIs include: TCE and degradation products; possibly tetrachloroethene (PCE) as an impurity within TCE. Other releases associated with Siltronic operations (1980-1997), also on the northern portion of the property, include chromium solution, acids, caustics, and organic wastewater releases or spills.

Off-Site Releases: Contaminants related to identified sources located south of the Siltronic property have been detected within groundwater at the Siltronic site, indicative of on-site migration. Off-site contaminants include: benzene, chlorobenzene isomers, dichlorobenzene isomers, MTBE, 2,4,5-TP, chloroform, TCE and degradation products.

Filling Activities: Site filling activities were conducted on the Siltronic property between 1966 and 1975. Filling involved placement of 1.5 million cubic yards of material on the property, including approximately 700,000 cubic yards of dredge spoils from unidentified locations and 800,000 cubic yards of material imported from a quarry. Depending upon origin, dredged sediments could reasonably have been impacted by many different sources of potential contamination, including ship traffic, industrial operations (such as MGP, wood treating facilities, shipyards, pesticide manufacturing, or petroleum terminals), agricultural activities, or urban run-off. During the time of filling activities, the property was owned by Mr. Victor Rosenfeld and Mr. H.A. Anderson.

In addition to possible sources of impact from the dredged sediments or other imported materials used as fill, observations of tar or oil during various investigations or construction activities at the Siltronic site, as well as dark soils visible in aerial photographs between 1967 and 1971, suggest the possibility that MGP-related wastes from the 400-foot wide lowland area may have been redistributed and combined with fill placed at various portions of the Siltronic property during filling activities (1966-1975), after NW Natural sold the property in 1962.

1.3 Hydrogeologic Framework

Groundwater occurs in three hydrologic zones beneath the Siltronic site: the unconfined surficial fill water-bearing zone (WBZ), the semi-confined alluvial WBZ, and the confined bedrock aquifers of the Columbia River Basalt Group.

Surficial fill consists of 700,000 cubic yards of dredge materials and 800,000 cubic yards of other imported materials. The surficial fill appears to have been impacted throughout the site by the placement of contaminated dredge spoils or other imported fill and/or by re-distribution of soils or other materials from the former lowland area at the northern end of the current Siltronic facility.

The overall groundwater flow direction within the surficial fill zone WBZ across a majority of the site is to the northeast, towards the Willamette River, where this zone becomes very thin to seasonally absent. A groundwater divide exists near the southern portion of the site, with flow within the surficial fill back to the south and toward North Doane Creek.

Responses to tidal fluctuations in the adjacent Willamette River are not expressed in the surficial fill WBZ, indicating this zone is isolated from the river. A downward hydraulic gradient between the surficial fill WBZ and the alluvial WBZ is typical, and groundwater in the surficial WBZ may migrate to the alluvial WBZ in areas where the intervening silt unit thins or otherwise does not impede downward flow.

Beneath the surficial fill WBZ, and defining the surface of the alluvial unit, is a laterally extensive fine-grained silt unit. The silt unit has been found to range in thickness from approximately 70 feet near the central portion of the site, thinning toward the river, where thicknesses of 1 to 3 feet are common at the riverbank. Beyond the riverbank, a thickening prism of silt has been identified extending 200 to 300 feet from the shoreline. It is expected that the fine-grained silt materials impede nearshore discharge of groundwater to the river. Vertical migration of contaminants through the silt unit has occurred at the northern portion of the Siltronic site (400-foot wide former lowland area), where the silt unit becomes thin and/or where the presence of rootlet zones has resulted in the fingering of non-aqueous phase liquid (NAPL) through the silt.

The alluvial WBZ consists of interbedded sands and silts underlying the silt unit, and ranges in thickness from 2 to 25 feet thick at the central and western portions of the site, to up to 175 feet near the northern corner of the site. Overall groundwater flow direction in the alluvial WBZ is to the northeast toward the Willamette River, with a more northern component of flow being present at the basal portions of the alluvial WBZ.

Water levels measured in offshore well points identified a predominant downward gradient throughout the alluvial WBZ beneath the Willamette River, indicating the river near the Siltronic property may be a losing reach. Further, distribution of COIs between the upland portion of the site and the Willamette River suggest a downward gradient below the river. Available vertical gradient data and contaminant concentration profiles adjacent to and beneath the river do not suggest the discharge of groundwater from intermediate to deep portions of the Alluvial WBZ to Willamette River sediments.

1.4 Subsurface Soils / Non-Aqueous Phase Liquid

Oil and tar, likely attributable to historical MGP waste management practices at the Siltronic site, have been identified near the base of the surficial fill unit and extending into, and beneath, the underlying silt unit within portions of the former 400-foot wide lowland area, where up to approximately 6 feet of oil have accumulated in a well screened to 85 feet below ground surface (bgs), and where oily soils have been observed as deep as 74 feet bgs. Further, dense non-aqueous phase liquid (DNAPL) has been identified in two alluvial WBZ wells screened to 125 feet bgs at a location between the former lowland area and the Willamette River. The area of deep DNAPL migration beneath, and down-gradient of, the former lowland area corresponds to the location of significant TCE concentrations in groundwater, suggesting the possibility of a co-solvency effect.

Oil or tar have not been identified beneath the silt unit at portions of the site beyond the 400-foot wide former lowland area. Further, no oil has been identified within the surficial fill unit or upper portions of the alluvial unit at any location between the former lowland area and the river sediments, and no evidence for the migration of oil or tar from the surficial fill unit to Willamette River sediments exists.

Direct observation of soil cores from upland and in-water borings indicate the upland DNAPL to be disconnected and separate relative to the shallow oily sediments identified at off-shore locations. Further, due to the depth of the DNAPL near the shoreline (well below the base of the river); the specific gravity of the DNAPL; and the apparent presence of a downward hydraulic gradient beneath the river, the DNAPL does not appear to be a future migration threat with regard to Willamette River sediments.

Available observational data and historical research indicate oil or tar-bearing sediments off-shore of the northern portion of the Siltronic property are likely the result of historical overflow from the former effluent ponds at the southern end of the current Gasco property via the former ditch located near the current Gasco / Siltronic property boundary (1941 to 1951), and from possible discharges related to the former lowland area via the ditch formerly located approximately 400 feet upriver from the property boundary (1951 to 1956).

In addition to the 400-foot wide lowland area, oil and tar have been identified within the surficial fill unit at other portions of the Siltronic property. With exception of the former Western Transportation area, the identified oil or tar is likely a function of the import of contaminated fill onto the site and/or the incorporation/redistribution of contaminants into the fill at the time of placement. Oil identified in soils at the former Western Transportation area appears to be the result of spills of diesel or fuel oil to the former ground surface from previous fueling operations conducted in that area.

1.5 Groundwater Quality

Oil and tar historically placed within the former lowland area as a result of effluent pond clean-out and overflow are a source area for identified aromatic hydrocarbon (e.g., benzene), PAH (e.g., naphthalene), and semi-volatile organic compound (SVOC) impacts identified within the fill and alluvial WBZs beneath this area, with a sharp decline in contaminant concentrations to the south, beyond the limit of the former lowland area. Additionally, the Olympic Pipeline release area is present within this portion of the site, and appears likely to be contributing to the identified aromatic hydrocarbon concentrations in groundwater.

Benzene and naphthalene, key constituents with regard to evaluating contaminant distribution that may be related to the oil and tar, have been used, in part, to describe contaminant extent within groundwater beneath the Siltronic site. With this regard, the benzene plume extends to the Willamette River shoreline within the surficial fill WBZ only near the northern corner of the Siltronic site (down-gradient from the former lowland area), and then only at very low concentrations. The naphthalene plume does not extend to the Willamette River shoreline within the surficial fill WBZ at any location.

Vertical migration of petroleum hydrocarbon-related contaminants from the surficial fill WBZ to the underlying alluvial WBZ is limited to the northern portion of the Siltronic property, correlating to the area of deeper DNAPL (oil) penetration in the 400 foot wide lowland area. The hydrocarbon plume has been delineated laterally and vertically along the shoreline, extending across a depth interval of approximately 60 to 150 feet bgs, and laterally along the shoreline from a location north of the common property boundary with Gasco, to a location approximately 375 to 450 feet upriver of the property line, correlating with the location of the former lowland area.

Available data from in-water borings suggest the upland petroleum hydrocarbon plume is predominantly migrating beneath the river without discharge to shallow sediments, with the extent of the upland benzene and naphthalene plume components having been delineated in the upriver direction.

Directly impacted river sediments at certain areas off-shore of Siltronic appear to be acting as a primary source of dissolved phase naphthalene in the surface sediment porewater. These impacts, derived from placement of contaminated material at the surface, extend downward into the sediments, and based on the profile of decreasing concentrations with depth, may be a source of contamination to deeper groundwater. If groundwater discharging from the upland were the source of the observed porewater concentrations, concentrations would more likely increase, rather than decrease, with depth. Benzene and naphthalene impacts to groundwater at the southern and western portions of the Siltronic site are primarily limited to the surficial fill WBZ, with impacts extending to the south as a function of a localized southern component of flow toward North Doane Creek and North Doane Lake in this area. The source for the impacts identified at this portion of the site appears to be the presence of oily zones within imported fill.

Cyanide impacts to groundwater are present in the surficial fill WBZ across much of the Siltronic property, with the highest concentrations being identified at the central portion of the site and extending to the shoreline down-gradient of the former 400-foot wide lowland area. Within the underlying alluvial WBZ, concentrations greater than 0.5 parts per million (ppm) have been identified to depths of up to 100 feet bgs at the northern portion of the Siltronic site. One potential source for the identified cyanide impacts could be spent oxide / purifier box wastes formerly stored at the northern end of the property. However, imported fill is another potential source for the cyanide, especially since the greatest cyanide concentrations in soil (greater than 1,000 ppm) were identified in fill at areas well away from the area where spent oxide was stored, and soils containing the highest cyanide concentrations did not contain field screening evidence of the presence of MGP-related materials (e.g., no wood chips, spent lime, prussian blue coloration, tar or oil).

1.6 Identification of Potential Contaminant Transport Pathways

Based on the preceding, potential contaminant transport pathways between the upland portion of the site and the Willamette River, to be further evaluated as part of an updated source control evaluation document, include the following:

- Groundwater Pathway
- Surface Water Runoff Pathway (e.g., Site Outfalls and City of Portland Outfall 22C)
- Catch-Basin Sediment Transport Pathway
- Soil Erosion Pathway (unarmored areas of embankment)

1.7 Preliminary Data Gap Identification

The following areas have been identified where additional data appear needed to fully support completion of a source control decision at the site with regard to former MGP-related waste management areas.

- Due to the potential for shallow groundwater to discharge to North Doane Creek and/or into the large diameter buried pipe leading to the Willamette River at City of Portland Outfall 22C, additional surface water investigation activities are currently being conducted as per a previously-approved work plan. Results of these investigation activities, as well as source control evaluation related to this feature, will be reported under separate cover.

- The lateral extent of the petroleum hydrocarbon plume beneath the river at the northern portion of the Siltronic property (former lowland area) has not been delineated in the down-gradient direction off-shore to the northeast, and it is not clear what the groundwater discharge/recharge regime may be with regard to this plume further into the main channel. It is anticipated that additional off-shore characterization will be necessary to satisfy these data gaps.

- Additional groundwater quality characterization down-gradient of the former depression/excavation area south of the former lowland area is warranted in order more completely to evaluate the potential for deep impacts (e.g., greater than 100 feet bgs) that may be attributable to this area.

- Additional investigation activities appear warranted with regard to the former spent oxide storage pile area to evaluate whether cyanide impacts from historic spent oxide storage may be contributing to the cyanide concentrations observed in groundwater at the site.

2.0 INTRODUCTION

2.1 Purpose

NW Natural retained Hahn and Associates, Inc. (HAI) to complete Focused Remedial Investigation (RI) activities at the Siltronic Corporation (Siltronic) property, 7200 NW Front Avenue, Portland, Oregon (Figures 1 and 2). Focused RI activities at the property have been completed as per a Unilateral Order (DEQ No. ECVC-NWR-00-27) issued jointly to NW Natural and Siltronic by the Oregon Department of Environmental Quality (DEQ), dated October 4, 2000. The purpose of the Order is to provide for completion of RI activities sufficient in scope to "determine the nature and extent of releases of hazardous substances to Willamette River sediments from certain property in Multnomah County, and to develop and implement source control measures, if necessary."

Based on the preceding, the objectives of the Focused RI activities completed by NW Natural at the Siltronic property have been established as follows:

- To identify, characterize, and estimate the magnitude of any ongoing un-permitted discharges of hazardous substances from the Siltronic site to the Willamette River sediments.
- To obtain sufficient information to allow for an evaluation of the need to implement source control measures at the site necessary to prevent the ongoing discharge of unacceptable levels of hazardous substances, if any, to Willamette River sediments.
- To characterize sources of identified ongoing unacceptable risk to Willamette River sediments for the purpose of evaluating, developing, and implementing source control measures sufficient in scope to provide for the mitigation of the identified unacceptable risk.

NW Natural is conducting those portions of the investigation relevant to possible manufactured gas plant (MGP)-waste management related impacts. Siltronic is conducting investigatory activities related to chlorinated solvent impacts identified during the Focused RI. NW Natural understands that activities related to Siltronic's chlorinated solvent-related investigation will be documented by Siltronic and will be submitted independently by Siltronic to the DEQ.

An earlier version of the *Phase I Site Characterization Report* was provided to DEQ on November 7, 2003 (HAI, 2003), as was a November 2003 *Source Control Evaluation Report* (Anchor, 2003). DEQ provided comments on the November 2003 *Phase I Site Characterization Report* in correspondence dated April 23, 2004 (DEQ, 2004). Accordingly, the *Updated Phase I Site Characterization Summary Report* has been revised in response to DEQ's comments. Further, because additional information was collected by Siltronic with regard to the characterization of soils and groundwater at the nearshore downstream portion of the site in 2003 and 2004, DEQ requested that NW Natural wait to complete the *Updated Phase I Site Characterization Report* until these results were available and could be incorporated. Results of these additional investigatory activities have been incorporated into this updated report. The updated information provided herein will form the basis for revisions to the November 2003 *Source Control Evaluation Report* completed for the subject property by Anchor.

2.2 Scope of Work

The Focused RI work activities summarized in this report, primarily carried out at the site between August 2001 and July 2002, were performed in accordance with a DEQ-approved document entitled *Final Focused Remedial Investigation Work Plan, Wacker Siltronic Corporation Property, 7200 NW Front Avenue, Portland, Oregon,* dated June 1, 2001 (HAI, 2001) and a March 7, 2002 *Supplemental RI Work Plan* (HAI, 2002). The overall scope of work for investigatory activities conducted by NW Natural at the Siltronic property included the following:

- Completion of a geophysical survey along the riverfront at inferred locations of former creek channels and utility corridors;
- Installation of 11 push probe borings (P-1 through P-11) for soil and/or groundwater sampling along the Willamette River shoreline down-gradient of potential contaminant source areas;
- Installation of 3 monitoring wells (WS8-33, WS8-59, and WS-9-34) along the Willamette River shoreline for the purposes of evaluating seasonal trends in water quality and groundwater elevations;

- Completion of rising-head aquifer slug tests on the 3 newly installed monitoring wells for the purpose of estimating hydraulic conductivities;
- Completion of a short-term (2-week) continuous measurement water elevation monitoring event at select Siltronic and NW Natural wells, and the Willamette River;
- Collection of 5 surface soil samples at the top of the embankment along the Willamette River shoreline;
- Collection of sediment samples from 2 stormwater catch basins;
- Collection of a soil sample from beneath the Fab 2 area stormwater outfall;
- Collection of stormwater samples from the Fab 1, Fab 2, and Administration Building outfalls;
- Laboratory analysis of soil, catch basin sediment, surface water, and groundwater samples for VOCs; SVOCs, metals, and cyanide;
- Discussion with Siltronic personnel regarding observations of soil and subsurface conditions during facility development and operation;
- Historical aerial photograph review and evaluation of potential waste placement activities;
- Compilation and evaluation of subsurface data available for the site as generated by others as part of numerous other investigations conducted at the site.

2.3 Report Organization

This report is organized as follows:

- Section 1 is the Executive Summary, which describes the primary findings and conclusions of the completed investigatory activities
- Section 2 provides a summary of the purpose, objectives, and scope of work for the investigation activities, as well as a description of the report's organization.
- Section 3 provides a summary of site background, including site description and a review of known potential contaminant sources, contaminants of interest, and identification of potential contaminant migration pathways to the Willamette River.
- Section 4 provides a summary of the site characterization activities conducted at the site by NW Natural and others.
- Section 5 describes the analytical testing and data validation conducted as part of the investigation.
- Section 6 provides a summary of investigation results, including discussions regarding site hydrogeology and contaminant distribution, as it relates to the project objectives.
- Section 7 provides conclusions based on the investigatory activities completed to date, as well as a summary of existing data gaps and recommendations for additional investigatory activities.

3.0 SITE BACKGROUND

A summary of the site history, physical setting, potential contaminant sources, contaminants of interest, and potentially complete contaminant migration pathways between the uplands and the river are presented within this Section. All historical aerial photographs referred to herein are included in Appendix A.

3.1 Site Location and Description

Siltronic operates a silicon wafer fabricating facility on an 85-acre site along the western bank of the Willamette River in a section of northwest Portland zoned by the City as "Heavy Industrial".

The property, situated immediately northwest of the Burlington Northern / Santa Fe (BNSF) railroad bridge, is generally rectangular in shape. Property boundaries include the Willamette River to the northeast; BNSF railroad berms to the southwest and southeast; and a property line shared with NW Natural and Koppers Industries, Inc. (KII) to the northwest (i.e., the former Gasco-facility property). US Highway 30 (NW St. Helens Road), an automobile storage facility, a former rock quarry, and the Tualatin Mountains lie beyond the BNSF right-of-way to the southwest. Beyond the southeastern BNSF right-of-way lie the Rhone-Poulenc/Aventis CropScience, ESCO Corp., Gould / NL Industries, and Elf Atochem North America properties, all of which are undergoing environmental investigation and/or cleanup.

Presently, the Siltronic site is approximately 50% to 60% developed with two silicon wafer fabrication plants (Fab 1 and Fab 2) and associated wastewater treatment plants and structures, as well as an administration building, storage buildings, parking facilities, and a Portland General Electric (PGE) substation (Figure 2).

Additional site features include a narrow greenway that has been created along the full riverfront portion of the property, as well as an approximate 100-foot wide City of Portland utility easement that divides the property from the northwest to the southeast (Figure 2). Underground utilities that exist within the City of Portland easement include oil, gasoline, natural gas, water, and sewer pipelines, as well as electric and telephone cables.

3.2 Pre-Development Conditions

According to a Site History report prepared by the Portland Development Commission (PDC, 1985), with the exception of the adjacent railroad construction, the Siltronic site remained primarily undisturbed prior to 1900. The southern portion of the undeveloped property contained part of a small, shallow lake (reportedly less than 5 feet deep) known as Doane Lake, which was bisected by the present BNSF railroad bridge at the time of its construction in 1906 (see Figure 1 and the 1936 aerial photo). The remainder of the property consisted primarily of low lying wooded wetlands, prone to seasonal flooding. The PDC report indicates that a small creek traversed the property, with its source being the Tualatin Mountains immediately across NW St. Helens Road in what is now Forest Park. As depicted in aerial photographs of the site taken in 1936 and 1940, it appears that Doane Lake was an additional headwater for this creek.

Additionally, a 1906 elevation survey map (pre-development) of the adjacent Portland Gas & Coke Company (PG&C) property to the northwest of the present-day Siltronic site, depicts a small northwest-southeast trending creek situated approximately midway between the Tualatin Mountains and the Willamette River. Although the map does not extend its coverage to the present day Siltronic property, it would seem likely that this creek would be a drainage associated with the former Doane Lake located at the southwest corner of the Siltronic property. As evidenced by 1936 and 1940 aerial photographs, with the development and partial filling of the PG&C property (circa 1913), this creek was diverted to the northeast, flowing into the Willamette River near the present day NW Natural / Siltronic property line until 1951, at which time the creek was diverted approximately 400 feet further upstream (Figure 3).

3.3 Ownership, Filling and Site Development Activities

PG&C purchased the current NW Natural Gasco property (then undeveloped) in 1910. PG&C built and operated an oil gasification facility on the current NW Natural portion of the property between 1912 and 1956. Company records indicate that site preparation involved the filling of approximately 10 acres of low-lying land (south and western portion of the current Gasco property) with 205,381 cubic yards of material dredged from the Willamette River. Pre-development site conditions, as well as site filling activities, are shown in photographs dated 1912 (Appendix A).

Based on a Title review conducted by the Portland Development Commission (1985), PG&C purchased a portion of the current Siltronic site from the Spokane, Portland, and Seattle Railroad in 1939. NW Natural sold the property in 1962 to Mr. Victor Rosenfeld and Mr. H.A. Anderson, who subsequently sold the property to the City of Portland, Portland Development Commission in 1978. Siltronic purchased the property from the City of Portland in 1978.

As provided within a Bridgewater Group report entitled *Supplement to DEQ's Strategy Recommendation for the Wacker Siltronic Facility* (Bridgewater Group, 2000), filling activities associated with the Siltronic property were initiated in May 1966 and were completed by December 1975. The property owners (Rosenfeld and Anderson) had an agreement with the Spokane, Portland, and Seattle Railroad to fill the property to a minimum elevation of 30 feet mean sea level (msl) by the end of 1973, and to construct industrial buildings on the property by the end of 1978 (PDC, 1985).

Approximately 1.5 million cubic yards of imported material were placed on the Siltronic property as part of filling activities (Bridgewater Group, 2000). The fill consisted of rock from a quarry located across Highway 30 immediately west of the site, as well as more than 700,000 cubic yards of material dredged from the river (from an unspecified location) by the Port of Portland (PDC, 1985). By 1967, as part of filling and site development activities, the channelized creek that formerly ran across the northern portion of the property had again been re-channelized to route water through a ditch and culverts around the southern edge of the Siltronic property, where it currently discharges to the Willamette River at an off-site location through City of Portland Outfall 22C, located between the property's southern boundary and the BNSF Willamette River rail crossing. A 1978 aerial photograph provides a view of the Siltronic site subsequent to filling and prior to building construction.

Construction of Siltronic's new plant began immediately after the property was purchased in 1978 with plant operations commencing in March 1980.

The facility infrastructure presently includes manufacturing, administrative, and storage structures, wastewater treatment facilities, parking, and an electrical substation. Facility-related underground utilities include water, natural gas, sewer, and electric. Site utilities that intercept, or nearly intercept, the river embankment are as follows (from down-stream to up-stream):

- Combined effluent outfall (Fab 1 area stormwater and treated process effluent);
- Fab 2 area stormwater outfall;
- 16-inch diameter abandoned natural gas pipeline (pre-development);
- Administration Building downspout outfall;
- 96-inch diameter abandoned concrete masonry sewer pipe (pre-development – a former City of Portland sewer line).

These utilities, as well as other site utilities (e.g., water, gas, sewer), are depicted on Figure 4.

3.4 Background - PG&C Operations and Waste / By-Product Generation

PG&C built and operated an oil gasification plant on the current NW Natural property, north of the Siltronic property, between 1912 and 1956. PG&C owned a portion of the Siltronic property from 1939 until 1962, during which time company records and aerial photograph review indicate waste management activities were conducted on the northern portion of the Siltronic property proximate to the current NW Natural / Siltronic property boundary. No MGP production areas were located on the footprint of the current Siltronic property.

In order to better understand the nature of MGP-related waste management areas historically located on the Siltronic property, PG&C historical operations, including a description of products, by-products, and wastes, are described herein.

An extensive description of the production methods used at the PG&C Gasco site as part of oil gas manufacture is provided within an August 1939 document entitled *Report on Portland Gas & Coke Company* (Ebasco Services, Inc. and PG&C Co.); a 1941 paper entitled *Aromatics, Gas and Coke from Heavy Petroleum* (Hall, 1941); and a 1952 paper entitled *Oil Gas Manufacture, A Staff-Industry Collaborative Report* (Hull and Kohlhoff, 1952). The following summary of historical MGP operations at the Gasco site was primarily obtained from review of these sources, as well as available historical company records.

Table 1 identifies by-products or wastes generated by the Gasco MGP, including a description of the material and the associated contaminants of interest.

The Gasco facility used the "Pacific Coast Oil Gas Process" throughout the plant's life. This process involved thermal cracking of oil at near atmospheric pressure in a cylindrical shell containing heated refractory checker brick. In this process, heavy oils were introduced to the gasified vessel after pre-heating the checker brick to 2,000°F. These oils were then thermally cracked as they moved downward through the gasifier producing gas, lampblack, and tar. The lampblack and tar were subsequently removed from the gas after which the gas passed through purifiers where sulphur and other impurities were removed. The lampblack was recovered in wash boxes or thickeners, dried, and then fed to a rotary press, producing cylindrical or pillow shaped briquettes.

In 1923, the gasification process was modified to optimize aromatic generation and light oil recovery for use as motor fuel. Tar recovery and refining were incorporated into the process in 1925 to provide tar for use as a road binder. In 1941 a coke oven was installed at the plant to generate electrode grade coke and high BTU oil gas from feedstock oil (PS-400) and lampblack for re-forming in the existing retorts. The coke ovens produced oil gas and the by-products coke, tar, light oil, and creosote oil.

In addition to the preceding by-products, spent oxide (also called purifier box wastes) was generated from the use of iron oxide (iron-impregnated wood chips) or lime as solid reactants for the removal of sulfur from the oil gas. Spent oxide is primarily a blend of iron sulfides, sulfur, iron oxides and wood substrate and/or lime, however spent oxide material may also contain hydrocarbons that passed through the upstream gas processing equipment, as well as metals (typically arsenic, chromium, copper, lead, nickel, and zinc) and cyanides that would be removed from the gas along with the sulfur. Concentrations of cyanide gas, however, were of primary concern only within coal gas, and not at former oil gasification sites such as Gasco (Hayes, 1996).

Due to the large scale of operations at the Gasco site, economic recovery of many of the by-products typically wasted at other plants of this type was possible, thereby reducing the quantities of waste from this site. According to information provided within the 1952 Hull and Kohlhoff paper, gasification by-products were refined to produce the following products at the Gasco site:

- lampblack briquettes
- soft pitch
- specification tars and tar distillates
- specification creosote
- hard pitch
- electrode grade pitch
- crude naphthalene
- crude benzene
- motor fuel
- toluene
- xylene
- solvent naphtha

Appendix B provides a block flow diagram of products manufactured at Gasco in 1951. Also included in Appendix B are flow diagrams of various product refining and recovery processes, as obtained from a *Report on Generator Oil Gas Operations* presented by the Portland Gas & Coke Company to the American Gas Association in 1951 (PG&C, 1951).

Once natural gas became available in the 1950s, much of the MGP plant was shut down, with plant operations ceasing in 1956. With the arrival of natural gas, PG&C changed its name to the Northwest Natural Gas Company, and is now known as NW Natural. The Northwest Natural Gas Company constructed a liquefied natural gas (LNG) plant at the site in the late 1960's, at which time most of the old gasification plant was demolished and associated underground utilities were removed. Appendix B includes a map of the MGP layout at the time of closure in 1956.

3.5 Potential Contaminant Sources

The Strategy Recommendation report prepared by DEQ in October 1999 (DEQ, 1999), and the follow-up Supplement to DEQ's Strategy Recommendation report (Bridgewater Group, 2000), contain detailed summaries of previously identified site contamination, as well as a description of known chemical releases reported to have occurred at the Siltronic site subsequent to site development. An extensive review of historical MGP-related records and aerial photographs available for the property has also been conducted to evaluate areas of interest on the subject property.

Based upon these sources of information, a description of potential contaminant sources at the Siltronic property, including a description of one-time spills or releases known to have occurred at the Siltronic site, are provided below. Historical aerial photographs referred to herein are provided in Appendix A.

3.5.1 MGP-Related Waste Management Areas

PG&C owned a portion of the Siltronic property from 1939 until 1962, during which time company records and aerial photograph review indicate waste management activities were conducted at three locations on the northern portion of the Siltronic property proximate to the current NW Natural / Siltronic property boundary, as described below:

3.5.1.1 Former 400-Foot Wide Lowland Area

The area of primary interest on the Siltronic property potentially impacted by PG&C historical operations is an approximate 400-foot wide strip of former low-lying property located immediately south of the present day NW Natural / Siltronic property boundary (see Figure 3 and the 1952 aerial photo). The low area was bounded by a berm and apparent natural rise in ground surface in the up-river direction (e.g., approximately 400 feet from the present property line with NW Natural), as well as a rise in ground surface between the lowland area and the Willamette River.

Based upon historic company records, as well as interpretations of aerial photographs, MGP waste management-related activities are known to have occurred within the former 400-foot wide lowland area described above (approximately 10 acres), including overflow from the Gasco property settling ponds and placement of tar/lampblack derived from cleanout of the effluent ponds onto the ground surface in the 400-foot wide lowland area. Additionally, aerial photographs suggest lampblack storage at the Gasco site may have extended onto the extreme northern corner of the 400-foot wide lowland area (Figure 3).

The Gasco effluent ponds, materials from which apparently overflowed to or were placed upon the lowland area, were constructed at the southeastern portion of the current Gasco site in the late 1930s and came on-line in 1941 (CDM, 1987). Aerial photographs taken between 1952 and 1961 show one large and one small effluent pond (Gasco property) and the adjacent lowland area (Siltronic property). The effluent settling ponds on the Gasco property received wastes from tar boxes and lampblack dryers (tar, lampblack, and oil-water emulsions), and were meant to reduce the discharge of effluent to the river. As shown on the aerial photographs, the smaller effluent pond partially extended onto the Siltronic property (Figure 3).

PG&C records indicate the larger effluent pond was designed to overflow via a weir into the western end of the small effluent pond. This pond, in turn, was designed to overflow via a weir on the eastern end into a channel that directed discharge to the Willamette River at a point near the current NW Natural / Siltronic property line (Figure 3). Records indicate the top of the berms surrounding the effluent ponds ranged in elevation from approximately 21 to 26 feet msl (approximately 7 to 12 feet below the existing ground surface at Siltronic).

PG&C records further indicate that to maintain capacity within the effluent ponds and to minimize overflows into the river, the ponds were periodically cleaned-out. Effluent pond clean-out reportedly involved use of drag lines and trucks to place the “soft/tarry substance” on the ground surface immediately south of the ponds (i.e., the former adjacent low area at Siltronic). To further address effluent pond overflows to the river, in 1951 a surface water channel located immediately south of these ponds (at the current common property line between NW Natural and Siltronic) was relocated 400 feet further south with a berm constructed immediately north of the new channel. The southern effluent pond outlet that previously overflowed to the river near the NW Natural / Siltronic property line was blocked at that time, with effluent pond overflows instead being directed to the lowland area which roughly corresponds to the northern 400 feet of the present-day Siltronic property. As such, MGP effluents were directed to the northern portion of the present-day Siltronic property between 1951 and the time of MGP closure in 1956. Effluent overflows from the northern portion of the Siltronic site to the Willamette River during this timeframe, if any, would have likely occurred via the ditch at the southern end of the 400-foot wide lowland area. Figure 3 and aerial photographs from 1952 through 1964 depict the ponds and the adjacent lowland area and drainage ditch.

Facility records indicate that soundings taken by CH2M HILL with a 1.5-inch diameter probe in January 1960 identified between 0.6 feet to 14 feet of soft tar within the 400-foot wide lowland area (thickest in proximity to the small effluent pond located on the property line. Using these data, it is estimated that approximately 40,000 cubic yards of tar may have been present within the lowland area at that time.

As shown in aerial photographs, grading and filling of the lowland area on the Siltronic property began in 1966. Filling this portion of the Siltronic property appears to have taken place through 1973 (May and August 1973 aerial photographs). Fill material in the 400-foot lowland area included dredge material (1971 and May 1973 aerial photographs), and light-colored material that appears to have been imported by dump trucks (October 1966 and May 1973 aerial photographs).

3.5.1.2 Former Depression or Excavation

A 1955 aerial photograph depicts an approximate 150 foot diameter excavated area or depression surrounded by a dirt road in the east/central portion of the Siltronic property (Figure 3 and March 1955 aerial photograph). The dirt road appears to extend from the 400-foot wide lowland area to this depression (1955 and 1956 aerial photographs). The southern one-quarter of the depression is dark-colored (1956, 1961, and 1964 aerial photographs). Company records indicate that soundings within this depression taken by CH2M HILL in January 1960 show between 2 and 3 feet of tar on the ground surface, indicating that tarry wastes accumulated at this location. Based on the soundings data, it is estimated that approximately 2,000 cubic yard of tar may have been present within the depression subsequent to the cessation of all MGP-related activities at the Gasco site. The depression is not observed in photographs after 1964. The function of this depression / excavation is unknown.

3.5.1.3 Spent Oxide/Purifier Box Wastes Storage Pile

A stockpile of spent oxide/purifier box waste material was identified in aerial photographs of the site from the 1950s and 1960s, with the pile located near the southwestern end of the common property line currently shared between Siltronic and NW Natural. Company records indicate this pile contained an estimated 34,000 cubic yards of spent oxide material. The stockpile of dark-colored spent oxide material is first observed in 1952 (April and July 1952 aerial photographs), with most of the pile situated on the present-day Siltronic property. Aerial photographs indicate the stockpile was present at this location between 1952 and 1966, several years after NW Natural sold the property. The final disposition of this material is unknown.

3.5.2 Other Contaminant Sources

3.5.2.1 Former Western Transportation Terminal

Western Transportation, which operated a fueling dock at the southeast corner of the Siltronic Facility had two large above ground fuel tanks. The occurrence or manner of leaks, spills or waste disposal activities associated with the former Western Transportation facility are unknown; however, according to DEQ (1999), an EPA analysis of a 1970 air photo concluded that soils in this area were stained. The 1970 aerial photograph (Appendix A) indicates possible areas of discolored soils (partially obscured by shadows) within the immediate vicinity of the Western Transportation structures (Figure 3).

The specific types of fuel oil stored and dispensed at the Western Transportation facility are not known, but diesel oil or fuel oil would be typical for this type of operation. Diesel oil contains petroleum hydrocarbons, including benzene, toluene, ethylbenzene, xylene (BTEX) compounds, polynuclear aromatic hydrocarbons (PAHs), the bulk of which are of lower molecular weight, and PAH-related compounds such as methylnaphthalenes. Diesel oil may also contain trace amounts of metals (Potter and Simmons, 1998).

Site plans also indicate an abandoned pipeline in the vicinity of the former Western Transportation facility. Siltronic plans (Drawing P11054.A1, December 1978) depict a 16-inch diameter abandoned line labeled "G" that runs from the NW Natural property, across the Siltronic site, and to the embankment in the vicinity of the former Western Transportation facility. One other utility labeled as "G" on the Siltronic plan references an existing 10-inch diameter natural gas line. NW Natural maps, although they do not show the location of the 16-inch line on the Siltronic property, do indicate the installation of a 10¾-inch diameter natural gas line on the property in 1978, and the abandonment of a 16-inch natural gas line at the property in 1979. Based on the preceding, it appears reasonably likely that the utility line in the vicinity of the former Western Transportation facility carried natural gas. The location of this abandoned line is depicted on Figure 4.

3.5.2.2 Olympic Pipeline

The Olympic Pipeline utilizes two product lines within a utility corridor that traverses the central portion of the Siltronic property (Figure 2 and 4). Of these two pipelines, one is used to transport diesel and kerosene, while the other is used to transport gasoline. Based on previous activities associated with the pipeline as described herein, the Olympic Pipeline is a potential source of petroleum hydrocarbons in soil and groundwater in the western portion of the Siltronic facility (Figure 3). Diesel and gasoline contain BTEX and other monoaromatics. Diesel and kerosene contain PAHs, the bulk of which are of lower molecular weight, and PAH-related compounds such as methylnaphthalenes. Diesel oil may also contain trace amounts of metals (Potter and Simmons, 1998).

In February 1979, Siltronic discovered the presence of petroleum while excavating the foundation for a clarifier in the Fab 1 wastewater treatment plant area. An initial sample of impacted soil from the excavation was found to contain hydrocarbons that matched a sample of diesel fuel obtained from one of the pipelines, although a second sample apparently did not match the Olympic Pipeline product (DEQ, 1999).

Olympic Pipeline subsequently exposed its pipelines. Holes in the pipeline were found and floating oil product was identified within the utility corridor to the northwest and southeast of the Siltronic clarifier excavation. Olympic Pipeline replaced the leaking section of pipe, removed floating product from the excavation, and removed residual oil stained soils in the bottom of the clarifier excavation (Bridgewater Group, 2000). The approximate location of the Olympic Pipeline release is depicted on Figure 3.

During pre-construction activities in 1990, Siltronic discovered petroleum hydrocarbons in proximity to Olympic Pipeline's pipelines (MFA, 2002). In October 1990 on behalf of Siltronic, CH2M Hill conducted a groundwater and soil gas investigation in the vicinity of the pipelines (Figure 3). Temporary well points were installed at 29 locations (GW-1 through GW-29) and groundwater samples were collected from just below the water table. The samples were analyzed in a field laboratory. CH2M Hill concluded that the concentrations of BTEX detected in the groundwater samples are typical of those associated with a gasoline spill or leak. The highest detected concentrations of BTEX and TPH were located adjacent to the utility corridor, indicating that the source of BTEX contamination may be located in that area (CH2M Hill, 1990).

Data from the 1990 investigation was provided to DEQ and Olympic Pipeline. In 1991, Olympic Pipeline pressure-tested the pipelines. One of the pipelines ruptured during the test. Both pipelines were replaced and the old pipelines were abandoned in-place (Bridgewater Group, 2000).

In summary, there is a confirmed release from the Olympic pipeline at the Siltronic property. The location of the release is proximate to the 400-foot former lowland area, thereby resulting in the likely commingling of contaminants, with benzene both from the pipeline release and potentially from MGP-residue placement, being collocated at this area.

3.5.2.3 Fill Material

As discussed in Section 3.3, filling activities associated with the Siltronic property were initiated in May 1966 and were completed by December 1975. Approximately 1.5 million cubic yards of imported material were placed on the property as part of filling activities (Bridgewater Group, 2000). The fill consisted of rock from a quarry located across Highway 30 immediately west of the site, as well as more than 700,000 cubic yards of material dredged from the river (from an unspecified location) by the Port of Portland (PDC, 1985). The dredged sediments and potentially materials from other offsite sources may have contained hazardous constituents that have impacted the Siltronic property.

As observed on 1967 and 1968 aerial photographs, coincident with on-going filling activities, dark-colored areas are shown extending across the western and central portions of the Siltronic property (Figure 3). Although the nature of the dark-colored material is not documented, it may be indicative of the placement or re-distribution of impacted soils or dredge materials as fill at the site. As described above, 1.5 million cubic yards of imported fill of unknown quality were placed at the site. Depending upon origin, dredged sediments could reasonably be impacted by MGP, wood treating, shipyard, pesticide, or petroleum terminal-related impacts. During the time of filling activities, the property was owned by Mr. Victor Rosenfeld and Mr. H.A. Anderson (Section 3.3). No documentation regarding any filling activities at the Siltronic property was identified within NW Natural company records.

In addition to possible sources of impact from the dredged sediments used as fill, observations of tar or oil during various investigations or construction activities at the Siltronic site also suggest the possibility that MGP-related wastes from the 400-foot wide lowland area may have been redistributed and combined with fill placed at various portions of the Siltronic property during filling activities (1966-1975) after it had been sold by NW Natural in 1962.

Evidence of petroleum-impacted fill at the site was first described within geo-technical borings installed at the at the Siltronic property in 1977 (CH2M HILL borings B-1 through B-3), prior to the purchase of the property by Siltronic. Further, impacted soils have been observed during construction activities conducted at the site.

According to Mr. Tom McCue, Environmental Manager for the Siltronic site, during construction of the Fab 2 building and related structures (e.g., wastewater sump) in 1995, Siltronic encountered soil impacted by petroleum hydrocarbons, tar residue, and high-carbon solids. Visually-impacted soils were reportedly encountered in the Fab 2 areas as shallow as 6 feet bgs, with soils appearing black with apparent black patches of oil. Mr. McCue further indicated that visually-impacted soils were similarly identified during construction of the site’s wastewater treatment sump (near monitoring well WS-10), with black soils extending across a depth interval of 12 feet to 24 feet bgs (McCue 2004, pers. comm.).

As described in a document entitled *Petroleum Contaminated Soils Treatment Report* (Deaver Environmental Group, Inc., 1995), during construction of the Fab 2 structure, approximately 5,490 tons of contaminated soil were segregated and thermally treated on-site consistent with Petroleum Contaminated Soil Treatment Permit No. PCSLA-NWR-95-004 (the PCST Permit) obtained from the DEQ. Data from the report indicate the impacted soils contained benzene (prior to treatment) ranging in concentration from non-detect to 8.2 parts per million (ppm) and diesel-range petroleum hydrocarbons ranging in concentration from 60 to 30,000 ppm.

Finally, on July 29, 2000, an oil sheen was created on the Willamette River at a location immediately adjacent to the Siltronic site as silt was being dredged as part of bank repair work being conducted by Siltronic. Analysis of sediment samples identified gasoline (7.5 to 69 ppm), diesel (399 to 5,810 ppm), and heavy oil (293 to 2,970 ppm) petroleum hydrocarbons. In total, approximately 115 tons of sediments were disposed as petroleum-contaminated waste (Bridgewater Group, 2000). The location of the dredging-induced sheen, located upstream of the former channelized creek discharge (1951-1967), is depicted on Figure 3.

As discussed in the previous sections, primary potential sources for petroleum-contaminated soils encountered during site development activities are impacted fill placement, Olympic Pipeline petroleum release(s), and the relocation and use of MGP materials for fill after NW Natural sold the property in 1962.

3.5.2.4 Siltronic Operations-Related Chemical Releases

Siltronic has reported several hazardous substance releases in connection with its operations, as follows:

1980 Chromium Release

On December 16, 1980, chromic acid was found within the Siltronic wastewater treatment plant concentrated acid system. An estimated 5.5 pounds of chromium was captured and taken to the Arlington hazardous waste landfill for disposal. Although no chromic acid was reportedly released to soil underlying the wastewater treatment plant, an estimated 1.3 pounds of chromium was discharged to the Willamette River through the combined effluent outfall near the northern corner of the property (Figure 4). According to Bridgewater Group (2000), Siltronic conducts permitted discharges of chromium to the Willamette River of up to 11 pounds per year.

1981 Chromic and Nitric Acid Leak

Approximately 6,000 gallons of acid etch solution and rinse water were spilled at the Materials Characterization Production Area (Fab 1 Building) at the Siltronic site in 1981, with some of the spilled material being collected within a sump, while the remainder was reportedly collected within the overfilled above-ground storage tank’s secondary containment. No release to underlying soil or surface water was documented as a result of this spill (Bridgewater Group, 2000). The approximate location of this release is depicted on Figure 3.

1984 Trichloroethene Spills and Underground Storage

According to Bridgewater Group (2000), spills at the Siltronic facility's trichloroethene (TCE) stripper unit (immediately west of the Fab 1 Building) occurred on December 3, 1984 (0.33 gallons) and again on December 31, 1984 (11.6 gallons). As a result of these spills, Siltronic removed 128 cubic yards of soils, with the removed soils transported to a hazardous waste landfill in Arlington, Oregon. Confirmation soil samples indicated the presence of less than 1 part per million (ppm) TCE remaining in the soil. No groundwater sampling was conducted. Siltronic received a letter of "No Further Action" regarding the TCE spill from the DEQ in 1985. Siltronic ceased the use of TCE at the facility in 1988 (Bridgewater Group, 2000). The approximate location of the TCE spills / area of soil removal are depicted on Figure 3.

As documented in a December 2002 report prepared by Maul Foster & Alongi, Inc. (MFA, 2002b), between 1981 and 1984, Siltronic utilized an underground solvent recovery system for TCE reclamation. This solvent recovery system included three underground storage tanks (USTs) which were physically removed in 1985 after start-up of the above-ground TCE stripper referenced above. No sampling was conducted as part of UST removal activities. Subsequent investigatory activities conducted by MFA on behalf of Siltronic have identified the former solvent UST system to be a source area for TCE impacts identified at the site (MFA, 2004). Investigatory activities conducted by MFA have identified TCE and associated degradation products within groundwater beneath the UST source area at the northern portion of the site, with the plume extending toward, and beneath, the Willamette River. Siltronic is currently evaluating the TCE-related impacts with regard to potential source control implementation. The location of the former UST system is depicted on Figure 3

1987 Organic Wastewater Overflow

Approximately 2,000 gallons of weak detergents and surfactants from the organic wastewater system overflowed onto a gravel yard and roadway on the Siltronic property in June 1987. The overflow entered a stormwater catch basin, with subsequent discharge to the Willamette River from the combined effluent outfall located near the northern corner of the property. Soil sampling in the spill area did not identify the presence of contaminants, and no cleanup was performed.

1988 Pentachlorophenol Detection in Wastewater

On January 11, 1988, pentachlorophenol (PCP) was identified within one of Siltronic's wastewater effluent samples at a concentration of 0.2 ppm. Follow-up sampling conducted on January 27, 1988 indicated the presence of PCP in a combined effluent sample at a concentration of 0.004 ppm. Further follow-up testing of the combined effluent in February, March, and April 1988, did not identify the presence of PCP at concentrations greater than the analytical detection limit of 0.005 ppm (Bridgewater Group, 2000). The source for the PCP identified within the wastewater effluent was not ascertained.

1991 Weak Acid Storage Tank Leak

Approximately 4,000 gallons of weak acid (spent, deionized rinse water) was released to the ground at the wastewater treatment plant area on September 11, 1991. Siltronic blocked all storm drains in order to contain the spilled material, after which approximately 1,000 gallons of the acid were recovered. DEQ concluded that the release was not a hazardous waste, did not exceed a reportable quantity, that no National Pollution Discharge Elimination System (NPDES) effluent limits were exceeded, and that further investigation would not be necessary (Bridgewater Group, 2000).

1997 Caustic Rinse Water Release

On April 28, 1997, caustic rinse water from an ion-exchange regeneration unit, containing an estimated 50 pounds of caustic (pH reportedly ranging from 7.4 to 11.3), was accidentally sprayed onto bare ground west of the Fab 1 building (Figure 3). The spilled caustic solution was neutralized, then recovered with a vacuum truck. Soil samples collected from the spill area indicated the presence of soils with a pH of up to 11.6, greater than the control sample pH of 7.6. Based on these results, the upper 6 inches of soil were scraped off. Re-sampling indicated remaining soils to have a pH similar to the control sample (Bridgewater Group, 2000).

3.5.3 Summary of Potential Contaminant Sources

Potential sources of contamination at the Siltronic property, based on reviews of the operational history of the site, facility plans, and aerial photographs, as described in the previous sections, are as follows (Figure 3):

<u>MGP—Related Waste Management Areas:</u>

- Tar and oil/water emulsions / lampblack placed by settling pond clean-out (1941 to 1956) or discharged by Gasco effluent pond overflow to the former lowland area extending approximately 400 feet south of the existing NW Natural/Siltronic property boundary (1951-1956);
- Tar placed within a small excavated area or depression south of the effluent pond overflow area as observed present in aerial photographs between 1955 and 1964 and in company records from 1960.
- Spent oxide storage (1952 to 1966) at the western corner of the Siltronic property.

Other Potential Contaminant Sources

- Incorporation of impacted soils/dredge material as a component of fill and/or redistribution of MGP residues from the 400-foot lowland area as part of site filling activities between 1966 and 1975, after NW Natural sold the property in 1962;

- Undocumented spills and waste management practices associated with the Former Western Transportation fuel terminal (1930-1950);

- Olympic Pipeline-related release area (1979 -1991);

- Releases and spills associated with Siltronic operations (1980-1997), all located within the northern portion of the Siltronic property (i.e., TCE, chromium, acids, caustics, and organic wastewater releases or spills);

3.6 Contaminants of Interest

Contaminants of Interest (COIs) for the Siltronic Focused RI were identified as follows:

- Polynuclear aromatic hydrocarbons (PAHs);

- Semi volatile organic compounds (SVOCs), including carbazole, dibenzofuran, 2-methylnaphthalene, and phenols;

- Volatile organic compounds (VOCs), including monoaromatic hydrocarbons [benzene, toluene, ethylbenzene, xylenes (BTEX)], tetrachloroethene (PCE), trichloroethene (TCE) and associated degradation products;

- Cyanide;

- Metals (antimony, arsenic, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, titanium, vanadium, and zinc)

PAHs and other semi-volatile organic compounds (SVOCs) are present in the by-products and residues of the oil gasification process, including heavy oils, tar, and lampblack. PAHs would also be a component of diesel fuels present within the Olympic pipeline and fuels historically stored at the Western Transportation Terminal. These constituents are also commonly present within fill materials imported from industrialized locales. Volatile aromatic hydrocarbons (e.g., BTEX) are present within motor fuels and light oils that were produced at the adjacent Gasco facility, as well as within fuels present within the Olympic Pipeline. Metals, particularly arsenic, chromium, copper, lead, nickel, and zinc, as well as cyanide are COIs relative to spent oxide / purifier box wastes, while chromium is also a COI because of Siltronic's use of chromium and a reported Siltronic chromic acid release. TCE and its degradation products have been included as COIs due to Siltronic's historical management of TCE and because these constituents have been identified in soil and groundwater at the Siltronic property. PCE has been included because it has been detected at several locations in soil and groundwater at the Siltronic site. No known use of PCE has been documented at either the Siltronic or the adjacent Gasco properties.

In addition to the preceding, other metals have been included as COIs because they were identified within the Strategy Recommendation Report (DEQ, 1999) as being present within sediments adjacent to the Siltronic site at concentrations considered to exceed the Portland Harbor baseline maximum values (e.g., cobalt, iron, manganese, selenium, silver, titanium, and vanadium), and/or because they have been used in Siltronic's fabrication process (e.g., antimony and chromium).

Conversely, herbicides, pesticides, and phthalates, identified within the DEQ Strategy Recommendation document as being present within adjacent sediments at concentrations exceeding the Portland Harbor Baseline, are not considered COIs for the purpose of this focused RI. Herbicides, pesticides, and phthalates are not contaminants of interest related to Siltronic operational or MGP-related contaminant sources.

3.7 Potential Contaminant Pathways to the Willamette River

Based on available site information, as described herein, potential contaminant migration pathways to the river, necessitating characterization and review as part of Phase I site characterization / source control evaluation activities, are as follows:

- Dissolved phase flux of chemicals to pore water or surface water via groundwater plume migration
- Dense Non-Aqueous Phase Liquid (DNAPL) migration to sediments/river
- Surface water runoff (from site outfalls) to sediments/river
- Erosion of embankment soils to sediments/river
- Preferential migration of chemicals to sediments or surface water along man-made features (utilities) or as groundwater discharge to North Doane Creek with subsequent flow to the City of Portland Outfall 22C.

4.0 FIELD ACTIVITIES

4.1 Geophysical Survey

On August 3, 2001, GeoPotential, Inc. of Gresham, Oregon, under contract to HAI, conducted a geophysical survey using a Mala RAMAC2 GPR (ground penetrating radar) system and 100 and 250 megahertz (MHz) antenna. The GPR survey had an effective depth of resolution to approximately 10 feet bgs.

The survey was conducted along a majority of the Siltronic riverfront including suspected locations of two former creek channels and known or suspected locations of numerous utility lines that extend to, or beneath, the river embankment. The purpose of the survey was to accurately determine the nature and spatial position of these features so follow-up soil borings could be optimally located to evaluate the possibility that these features act as preferred zones of contaminant migration. Approximate locations of major utility lines at the Siltronic property are shown on Figure 4.

Results of the geophysical survey indicated the location of the two active stormwater sewer lines that extend to outfalls on the embankment at the southern portion of the property, as well as the combined stormwater / process effluent line that extends across the river embankment near the northern property boundary. Each of these sewer lines was found to correspond with previously identified locations as provided on facility drawings. Two abandoned utility lines depicted on facility drawings as extending to the river across the southern portion of the property, were not identified by the GPR survey. Because these lines pre-date site filling activities, it is inferred that they are buried too deeply to be detected by GPR. Specifically, in some of the GPR survey areas the depth of fill is typically 25 to 35 feet-thick (e.g., 32.5 feet-thick at boring P-3) and therefore it is unlikely that the GPR survey, with an effective depth of resolution of about 10 feet, would be likely to directly identify the buried creek channels.

In addition to the preceding, the GPR survey identified a shallow zone of disturbed soil along the central portion of the embankment. A subsequent boring (P-11) through this area did not reveal any significant features. Based on a conversation with Mr. Ken Kemper of Siltronic, the area of disturbed soil was later inferred to be the result of previous walkway repair in this area.

Finally, two additional zones of disturbed soils were identified that coincided with locations for the two former creek channels (Figure 3). These disturbed soil zones were interpreted to possibly be the result of subsidence in the embankment fill caused by settling within the underlying buried stream/ditch channel. In order to extend the effective depth of penetration for the GPR survey by avoiding much of the surficial fill, an additional survey was conducted at the base of the river embankment at the estimated location of the 1941 to 1957 channelized creek discharge (e.g., boring P-3 vicinity).

Results of the survey conducted by GeoPotential, including a map of the GPR profile locations and GPR profiles, are included in Appendix C.

4.2 Surface Soil Sampling Activities

To evaluate the potential for contaminant migration into the Willamette River adjacent to the Siltronic site via overland flow and erosion, on August 21, 2001 HAI collected soil samples at select locations along the top of the river embankment. Because a February 6, 2001 riverbank inspection conducted by HAI found the embankment slope to be heavily reinforced with rip-rap and the top of the slope to be covered with well established vegetation (a grass lawn), no areas of localized preferential surface water run-off / erosion into the river were identified. Based on the proceeding, five surface soil samples (S-1 through S-5) were collected at default locations correlating with every other push probe boring installed along the shoreline (i.e., borings P-1, P-3, P-5, P-7, and P-9), as depicted on Figure 4.

All surface soil samples were collected from the upper 3 inches of the ground surface below the vegetative layer. Detailed field methods employed to collect the surface soil samples are included in the Sampling and Analysis Plan, Appendix G of the RI Work Plan (HAI, 2001).

4.3 Catch Basin Sediment Sampling Activities

To evaluate potential impacts attributable to stormwater-related discharges, the RIWP proposed collection of sediment samples from three select on-site stormwater catch basins. The three catch basins selected for sampling were in proximity to former spills and/or chemical storage areas. Specifically, of these catch basins, one was located in the vicinity of the facility wastewater treatment plant (CB1); one was located in facility process area (CB2), including the area of the 1997 caustic solution spill and the 1984 TCE spill; and one was located adjacent to a bulk chemical storage area (CB3).

On June 14, 2001, representatives of Siltronic, NW Natural, and the DEQ conducted a reconnaissance of the Siltronic property to evaluate, in part, the stormwater catch basins designated for sampling. Based on these observations, NW Natural and the DEQ agreed to eliminate the sampling of the catch basin CB1 located adjacent to the facility's wastewater treatment plant. This basin was eliminated from the sampling program since it was visually apparent that this basin was being flushed with treated effluent from the wastewater treatment plant, and would therefore not likely yield a sample representative of stormwater runoff or spills from the surrounding area. Further, based on inspection of the surrounding area, it did not appear catch basin CB1 would be in an area likely to receive impacts from spillage of hazardous substances.

On June 18, 2001, Ms. Cathryn Young of Siltronic notified NW Natural that routine maintenance of site stormwater catch basins was ongoing, and that this maintenance would include clean-out of sediment from within the catch basins to be sampled as proposed within the RI Work Plan. Because NW Natural had not yet arranged legal access to conduct sampling activities, Ms. Young agreed that Siltronic would implement the catch basin sampling activities at CB2 and CB3 prior to clean-out.

Siltronic's catch basin sampling activities occurred on June 19, 2001, with oversight from Mr. Eric Blischke of the DEQ. All sampling activities were reportedly conducted in accordance with Section 9.3.2 of the RI Work Plan. Locations of the catch basins are depicted on Figure 4.

4.4 Stormwater Outfall Sampling Activities

One-time grab samples of stormwater discharge representative of each of the three facility outfalls were collected by HAI on August 22, 2001, as described below.

Sampling of the combined process water/stormwater outfall was conducted within a manhole located west of the Fab 1 structure (Figure 4). This sample location was selected based on information provided by Mr. Ken Kemper of Siltronic indicating water passing through this manhole would contain only stormwater, with no contribution from the wastewater treatment plant.

Sampling of the Fab 2 area stormwater outfall and the Administration Building roof drain outfall was conducted at the end of the discharge pipes immediately above the river embankment (Figure 4).

All samples were collected on August 22, 2001 during a storm event that resulted in 0.64 inches of precipitation, as reported by the National Weather Service for the Portland International Airport. The previous measurable precipitation event was 21 days earlier, on July 30, 2001, when 0.20 inches of rain were recorded.

In addition to the preceding, to further evaluate potential historical and/or ongoing releases attributable to on-site stormwater catch basins, a sample (no. -173) of surface soils located immediately below the existing on-site “Fab 2 Area” stormwater outfall, which discharges to the river embankment, was collected by HAI on September 19, 2001. The sample was collected in a wet soil covered area surrounded by a rip-rap berm and a rip-rap covered slope immediately below the concrete outfall pipe. Although proposed, no sampling adjacent to the Administration Building roof drain outfall was possible, as the surface underlying this outfall was completely covered with rip-rap.

Detailed field methods employed to collect the surface soil samples are included in the Sampling and Analysis Plan, Appendix G of the RI Work Plan (HAI, 2001).

4.5 Push Probe Boring Installation Activities

Eleven push probe borings (P-1 through P-11) were installed under the direction of HAI by Geo-Tech Explorations, Inc. to depths ranging from 20 to 100 feet bgs at select locations along the Siltronic shoreline between August 2, 2001 and August 20, 2001 (Figure 3). These borings were installed to evaluate subsurface hydrogeologic conditions and for collection of depth-discrete soil and groundwater samples.

With regard to an evaluation of zones of potential preferential contaminant migration between the upland portion of the site and the Willamette River, push probe borings P-1 and P-3 were placed at each of the two locations of the historical on-site channelized creek, while P-1 also provided for an evaluation of subsurface conditions adjacent to the utility corridor associated with the combined sewer effluent pipe. Other zones of potential preferential contaminant migration between the upland portion of the site and the Willamette River that were evaluated included the Fab 2 storm sewer utility corridor (P-6), the abandoned natural gas utility corridor (P-8), the abandoned concrete masonry pipe corridor (P-9), and the Administration Building downspout storm water drain line (P-10).

In addition to the preceding, boring locations were selected with an emphasis on portions of the site down-gradient of the former effluent ponds / filled lowland area (P-1 through P-3), and the former Western Transportation fueling facilities (P-7 and P-8). Furthermore, push probe boring locations P-1 through P-5 also provided coverage down-gradient from historical Siltronic operational-related spills (i.e., TCE and various acid spills), all of which occurred either in the vicinity of the Fab 1 Building or the wastewater treatment plant area.

Soil samples were collected from all push probe boring locations with the exception of P-11, where soils were screened solely for the purpose of identifying the origin of a “disturbed soil zone” identified as part of the geophysical survey (Section 4.1).

Depth discrete groundwater samples were collected from temporary well points installed within borings P-1 through P-9 (Figure 3). The groundwater samples were collected from multiple depth horizons ranging from 24 feet bgs to 100 feet bgs. All screen intervals are listed on Table 2. The temporary well point data were collected for vertical profiling of contaminant concentrations in groundwater, and to help select screen intervals for subsequent monitoring well installation work (Section 4.6).

Field methods employed to install, screen soils, and sample the push probe borings and temporary well points are included in Appendix G of the RI Work Plan (HAI, 2001). A summary of push probe construction is included on Table 2. Boring logs that describe the soils encountered and temporary well point construction details, are included in Appendix D.

4.6 Monitoring Well Installation and Sampling Activities

With the completion of groundwater and soil sampling activities associated with the push probe boring component of the RI in August, 2001 (Section 4.5), and the receipt of preliminary analytical results from the investigation, a meeting with representatives of NW Natural and DEQ was conducted on September 7, 2001 such that locations and depths of monitoring wells could be agreed upon. Expedited DEQ approval of proposed monitoring well locations was provided via this meeting in order to facilitate completion of well installation activities during the week of September 10, 2001, a time-frame requested by Siltronic since it would coincide with a shut-down of Siltronic's crystal growing plant. As agreed in the meeting, five monitoring wells would be constructed at the Siltronic site. Of these five wells, three (WS-8-33, WS-8-59, and WS-9-34) were to be constructed along the riverfront, while two (WS-10 series wells) were to be constructed up-gradient of the WS-8 series wells in the immediate vicinity of the former TCE spill / soil removal area.

Monitoring wells WS-8-33 and WS-8-59, screened within the surficial fill water-bearing zone (WBZ) and the alluvial WBZ, respectively, were installed under the direction of HAI by Geo-Tech Explorations, Inc. on September 12, 2001. Well WS-9-34, screened within the surficial fill WBZ, was installed on September 13, 2001. Siltronic refused NW Natural access with regard to installation of the WS-10 series wells, and therefore these wells were not installed at that time. Monitoring well locations are depicted on Figure 3.

Wells WS-8-33, WS-8-59, and WS-9-34 underwent development with a submersible pump on September 19, 2001. One year of quarterly groundwater quality and elevation data were obtained from these wells subsequent to installation. Specifically, groundwater sampling events at the three monitoring wells were conducted on October 9, 2001, December 13, 2001, April 3, 2002, and July 10, 2002, coincident with sampling at the adjacent Gasco site.

Details of the field methods employed to install the monitoring wells, and soil and groundwater sampling protocols, are included in Appendix G of the RI Work Plan (HAI, 2001). Boring logs that describe the soils encountered and well construction details, are included in Appendix D. A summary of the monitoring well construction details is included on Table 2. A summary of available water level measurements and groundwater elevations obtained from site and nearby wells are summarized on Table 3a (Siltronic wells); and Table 3b (Gasco wells), and 3c (area-wide, multi-party well event). Tables 4a and 4b include vertical gradient calculations for well clusters at the Siltronic and Gasco sites, respectively.

4.7 Aquifer Slug Testing Activities

On February 20, 2002, HAI conducted rising-head aquifer slug tests on monitoring wells WS-8-33, WS-8-59, and WS-9-34 to provide an approximation of hydraulic conductivity of the aquifer in the vicinity of these wells. The slug tests were performed by lowering a PVC slug into each well to displace the groundwater column. After the displaced water returned to the approximate original static water level, the slug was quickly removed from the well, simulating the instantaneous removal of a slug of water from the well. The water level recovery data was measured with the use of a pressure transducer placed near the base of each well and recorded with an electronic data logger. Two to four individual slug tests were conducted at each well location.

The recovery data were analyzed by the Bouwer and Rice (1976) solution method to calculate preliminary estimates of hydraulic conductivity using Aquifer Test Toolbox spreadsheet software from Creative Software Applications, Inc.

Slug test data and analysis sheets for the Bouwer and Rice analysis for wells WS-8-33, WS-8-59, and WS-9-34 are included within Appendix E.

4.8 Continuous Short-Term Water Level Monitoring Event

A continuous short-term groundwater elevation monitoring event was completed by HAI at the Siltronic and adjacent Gasco site over a two-week period from July 24, 2002 through August 7, 2002. This short-term groundwater elevation monitoring event involved measurement of water levels on a 15-minute frequency for the duration of the test using pressure transducers / data loggers placed within selected wells. Further, water levels were simultaneously recorded in the Willamette River to compare to the measured groundwater levels. River level measurements were collected using a pressure transducer placed in a temporary stilling well placed on a docking structure near the MW-4 well cluster immediately down-river of Siltronic at the NW Natural Gasco facility.

Finally, site-specific rainfall and barometric pressure data were collected during the course of the test from an existing weather station located on the adjacent NW Natural Gasco property. Sampling points included within the short-term continuous water level monitoring test are identified below, and are shown on Figure 3.

Monitoring Point	Water-Bearing Zone
WS-8-33 (Siltronic)	Surficial Fill
WS-8-59 (Siltronic)	Alluvial
WS-9-34 (Siltronic)	Surficial Fill
MW-4-56 (Gasco)	Alluvial
MW-8-29 (Gasco)	Surficial Fill
MW-8-61 (Gasco)	Alluvial
Willamette River (Gasco)	-

Hydrographs depicting river and groundwater elevations, as well as rainfall events, measured during the monitoring event, are included in Appendix F.

4.9 Other Investigations

A number of investigatory activities other than those completed by NW Natural as per the Joint Order have been completed at the Siltronic site to date. These investigations relate to both geo-technical as well as environmental evaluations. A description of the pre-Joint Order investigations was previously provided within the RI Work Plan (HAI, 2001), and as such, this information is not repeated herein.

Siltronic is conducting an investigation of chlorinated solvents in groundwater down-gradient of the Fab 1 structure:

- In March 2002, Limno-Tech, Inc. (LTI) installed 3 push probe borings (GP-2-01, GP-2-02, and GP-2-03) to depths of 100 feet bgs and collected soil and groundwater samples (MFA, 2002b).

- In September and October 2002, MFA installed 4 push probe borings (GP-4 through GP-7) to depths of 100 feet bgs and collected soil and groundwater samples (MFA, 2002b).

- In July 2003, MFA installed 4 push probe borings (GP-8 through GP-11) to depths ranging from 25 feet bgs to 96.5 feet bgs and collected soil and groundwater samples (MFA, 2003).

- In September and October 2003, MFA installed 7 groundwater monitoring wells at the site (WS-10-27, WS-11-125, WS-11-161, WS-12-125, WS-12-161, WS-13-69, and WS-13-105) using rotosonic drilling methods. Screening level exploratory groundwater quality samples were collected with use of a packer assembly in the initial deep borehole for each well or well cluster. Of the monitoring wells installed, 1 well (WS-10-27) was installed within the surficial fill unit to a depth of 27 feet bgs, while the remaining 7 wells were installed within the alluvial unit to depths ranging from 69 feet bgs to 161 feet bgs (MFA, 2003).

- In June and July 2004, MFA installed 13 shallow push probe borings (GP-12 through GP-24) within the surficial fill unit to depths ranging from 20 to 30 feet bgs with the collection of soil and groundwater samples (MFA, 2004a).

- In July and August 2004, MFA installed 8 groundwater monitoring wells at the site (WS-14-125, WS-14-161, WS-15-85, WS-15-140, WS-16-125, WS-16-161, WS-17-52, and WS-17-94) using rotosonic drilling methods. Screening level exploratory groundwater quality samples were collected with use of a packer assembly in the initial deep borehole for each well or well cluster. Of the monitoring wells installed, all were installed within the alluvial unit to depths ranging from 52 feet bgs to 161 feet bgs (MFA, 2004b).

- In October 2004, MFA installed 8 push probe borings (GP-25 through GP-32) to depths ranging from 110 to 160 feet below the mudline within the Willamette River at locations down-gradient of the TCE plume, with collection of sediment and groundwater samples (MFA, 2005).

Locations of borings and monitoring wells installed by HAI, LTI , MFA and others at the Siltronic property, in addition to borings/wells at the adjacent Gasco property, are depicted on Figure 3. Available boring logs that describe the soils encountered at the boring locations located on the Siltronic property are included in Appendix D. A summary of the available construction details for all boring locations at the Siltronic property are included within Table 2.

5.0 ANALYTICAL TESTS

Soil and water samples collected by HAI and LTI as part of Focused RI activities at the subject site were shipped with chain-of-custody documentation in sealed and chilled containers to Environmental Services Laboratory, Inc. (ESL) of Portland, Oregon for analysis. Samples collected by Siltronic (stormwater catch basin sediment), were shipped with chain-of-custody documentation to Coffey Laboratories, Inc., Portland, Oregon for analysis. Samples collected by MFA were shipped with chain-of-custody documentation to Columbia Analytical Services, Inc. of Kelso Washington for analysis.

With regard to HAI activities, all samples were collected and analyzed in accordance with the Soil and Water Sampling and Analysis Plan included in the *RI Work Plan* (HAI, 2001). Samples collected by MFA were collected and analyzed in accordance with a September 2002 work plan (MFA, 2002a).

Soil and water samples collected by HAI and LTI were analyzed as follows:

- PAHs by U.S. Environmental Protection Agency (EPA) Method 8270 SIM;
- SVOCs by EPA Method 8270C;
- VOCs by EPA Method 8260B;
- Total cyanide by Method 9010;
- Select metals (antimony, barium, chromium, cobalt, iron, magnesium, mercury, nickel, selenium, silver, titanium, vanadium, and zinc) on a total basis by EPA Methods 6010 and 7470;
- Hydrocarbon identification (HCID) of total petroleum hydrocarbons (TPH) by Northwest Method TPH-HCID, with follow-up, as necessary for diesel- and oil-range petroleum hydrocarbons by NW Method TPH-Dx (soil only);

- Select samples were analyzed for chloride (EPA Method 325.3) and total organic carbon (D4129-82M).

Select soil and water samples collected by MFA were analyzed for PAHs by EPA Method 8270 SIM, SVOCs by EPA Method 8270, VOCs by EPA Method 8260B, and cyanide by EPA 9010.

The results of the above-described analytical testing for soil samples (surface, subsurface, and catch basin) collected by HAI, LTI, and MFA are summarized in Tables 5 through 9. Stormwater sampling results are included in Table 10. The results of groundwater sample analyses collected from temporary well points collected by HAI, LTI, and MFA are summarized in Tables 11 through 14. Results of quarterly groundwater monitoring activities for samples collected from Siltronic monitoring wells are summarized on Tables 15 through 18.

Analytical results for all samples collected by HAI underwent an independent EPA Level III validation, the results of which were provided within *Data Validation and Data Quality Assessment Reports*, prepared by Ms. Kathy Gunderson, dated June 11, 2002, and September 23, 2002 (Gunderson, 2002 a,b). These reports have previously been submitted to the DEQ and are not included herein.

6.0 SITE CHARACTERIZATION RESULTS

6.1 Geologic Setting

The geologic units of interest at the subject site can be subdivided as follows, from the ground surface downward:

- Surficial fill deposits
- Alluvial deposits

  Willamette river deposits

  Catastrophic flood deposits

- Columbia River Basalt Group (CRBG)

The site stratigraphy is depicted in nine generalized cross-sections (Appendix I) constructed across a majority of the subject property and extending to off-site locations both to the north and south. The locations for the nine cross-sections are shown on Figure 5.

6.1.1 Surficial Fill Deposits

It is estimated that approximately 1,500,000 cubic yards of imported material were placed on the Siltronic property as part of filling activities (1966 to 1975) (Bridgewater Group, 2000). The fill consisted of rock from the quarry located across Highway 30 immediately west of the site, as well as more than 700,000 cubic yards of poorly graded sands with gravel and silty sands dredged from an unknown portion of the Willamette River by the Port of Portland (PDC, 1985). In places the fill has been found to contain impacts potentially attributable to re-distribution of MGP residues at the site, and/or as a function of a multitude of sources that may have impact dredged sediments prior to placement on the site (e.g., current/former ship maintenance, pesticide manufacture, wood treatment, MGP, and petroleum transfer facilities are all located along the river in proximity to the site). All fill-related activities were conducted by others after NW Natural sold the Siltronic parcel in 1962.

A map depicting the thickness of the surficial fill unit across the Siltronic and adjacent Gasco sites is included as Figure 6. The thickness of the surficial fill unit across the site ranges from approximately 10 to 25 feet near the Tualatin Mountains (MW-12 to RP-3-61) to a maximum of 35 to 42 feet in the central – northern portion of the site, as observed at boring locations for wells WS-15 and WS-17. Along the bank of the Willamette River, the surficial fill unit ranges in thickness from approximately 24 to 34 feet at the Siltronic site. Fill identified adjacent to the river was predominantly found to consist of fine- to coarse-grained sand and gravelly sand, with occasional concrete, brick, or glass fragments. However, at several locations (i.e., borings P-1, P-7, P-10, RP-01, and RP-07), a much finer-grained material, predominantly a sandy silt to silt with occasional gravel, was identified.

With regard to tar or oil identified in fill adjacent to the river embankment, as depicted on cross-section E-E' (Appendix I), a 2.5 foot thick layer of tar was identified at the base of the fill at the P-1 boring location (former effluent pond overflow area), while a zone of oily fill (sand with gravel) was identified across a depth of 20 to 24 feet bgs at the P-4 boring location. Further, 1.5 feet of oily soils (patchy) were identified at the base of the fill (possible former ground surface) at the P-7 boring location (former Western Transportation fuel storage area). The nature of the tar or oil identified within the surficial fill unit at the Siltronic site is fully described in Section 6.4.

6.1.2 Alluvial Deposits

Underlying the surficial fill at the site are Quaternary-Age alluvial deposits, composed of unconsolidated sands and silts, that range in thickness from approximately 35 feet near St. Helens Road to a thickness of 170 to 175 feet (borings WS-12, WS-13, and WS-14) adjacent to the Willamette River near the northern corner of the Siltronic site. Additionally, the alluvial deposits thin towards the eastern corner of the site, where they were found to be 21 feet thick at the RP-1 boring location (cross-section E-E', Appendix I). These alluvial deposits have been differentiated by Geraghty & Miller (1991), into the Catastrophic Flood Deposits and Willamette River Deposits. The conceptual site model provided herein groups the two units together and refers to them as undifferentiated alluvial deposits. As the silt unit typically defines the top of the alluvial unit / base of the fill unit, the silt surface is considered to express the ground surface of the site prior to site development and filling activities.

The uppermost unit of the undifferentiated alluvial deposits in the vicinity of the site has been identified as a clayey silt by Camp, Dresser & McKee, Inc. (CDM, 1987), while Geraghty & Miller (1991) identified both silt and clay facies associated with the upper zone of the alluvial deposits. Borings installed at the Gasco and Siltronic properties have similarly identified a laterally extensive fine-grained silt unit, with minor clay content, at the upper portion of the Alluvial Deposits. Although laterally extensive across a majority of the Siltronic and Gasco areas, the silt unit has been found to be absent below some upland near-shore areas at the adjacent Gasco site (Figure 7). The silt unit is typically found to exhibit coloration ranging from olive gray to green, with some areas of orange-brown mottling, with small sand lenses and vertical rootlet zones present within portions of the silt unit.

Figure 7 provides elevation contours for the surface of the silt unit using all available data from both the Siltronic and the adjacent Gasco properties. As depicted on Figure 7, the surface of the silt unit generally slopes from all directions to the central portion of the Siltronic and Gasco sites, with the overall low being identified on the Siltronic property in the central portion of the former 400 foot-wide lowland area at the north end of the Siltronic property, where the top of silt was identified at an elevation of approximately -8 feet msl (boring WS-15). The silt surface rises from the WS-15 area in a riverward direction, reaching a crest beneath the Fab 1 building (at 9 to 12 feet msl), beyond which the surface slopes back down towards the river, with an elevation of between 2 and 6 feet msl identified adjacent to the riverbank at the northern portion of the property (cross-section B-B', Appendix I). Further, at the south-central portion of the property, the surface of the silt unit slopes to an apparent localized low point at the boring WS-3 area, where the top of silt is present at an elevation of -2 feet msl.

With regard to the riverbank area, as depicted on Figure 7 and cross-section E-E' (Appendix I), the surface of the silt unit was identified between depths of 25 to 35 feet bgs, with the surface rising approximately 10 to 12 feet higher across the upstream half of the property (e.g., south of boring P-5).

A map depicting the thickness of the upper silt unit across the Siltronic and adjacent Gasco sites is included as Figure 8. As depicted on Figure 8, the thickness of the upper silt unit is greatest throughout the central portion of the Siltronic property, where thicknesses of 67 feet (WS-10), 69 feet (B-104), and 56 feet (WS-3-81) were identified, and extending to the northwest where thicknesses of up to 43 feet (MW-14) have been identified on the Gasco site. The thickness of the silt unit at both the Siltronic and Gasco sites decreases in the direction of the Willamette River, where thicknesses of between 1 and 3 feet are common, or in some cases, the silt appears locally absent and/or transitions into a silty sand towards the shoreline (cross-section EE', Appendix I), becoming thicker at the shoreline and offshore of the shoreline (cross-sections A-A' and B-B', Appendix I)

Beneath the silt unit, the alluvial deposits are found to typically consist of sand with interbedded lenses of silt, sandy silt, or silty sand. The sands within the alluvial unit are described as grey in color with localized areas of brown coloration, fine-grained, well sorted / poorly graded, sub-round to angular, and locally micaceous. The silt / sandy silt lenses identified within the sand were typically grey in coloration, and typically contained rootlets and shell fragments. A thin layer consisting of medium to coarse-grained sandy gravel has been observed at the base of the alluvial deposits at both the Siltronic and adjacent Gasco sites.

6.1.3 Columbia River Basalt Group

The oldest and lowermost geologic unit of interest at the site consists of the Columbia River Basalt Group. The Miocene-age Columbia River Basalt Group, composed of a series of individual lava flows, generally forms the base (bedrock) of the Portland Basin and outcrops immediately to the southwest of the site in the Tualatin Mountains. The confined bedrock aquifers in the Columbia River Basalts have historically been of significance regionally.

A significant amount of bedrock surface elevation data are available for the former Gasco site, immediately to the northwest of the Siltronic property. Figure 9 provides elevation contours for the surface of the bedrock using available data from both the Siltronic and Gasco properties. These data indicate the basalt surface dips steeply to the northeast, with the top of the basalt occurring at a depth of approximately 36 feet bgs near the western corner of the Siltronic site (boring MW-12-36), to depths of 215 feet bgs near the northern corner of the Siltronic site (boring B-1-8). Although, in general, the bedrock surface is anticipated to dip steeply from the Tualatin Hills towards the Willamette River, undulations in the surface are observed.

Investigatory activities conducted by Geraghty & Miller (1991) near the southern corner of the Siltronic property, as well as results of investigatory activities completed by URS Greiner Woodward Clyde (URS) along the southeastern Siltronic property boundary, indicate the presence of a bedrock high, with the bedrock surface occurring at a depth of 108 to 115 feet bgs near the locations of wells RP-7 and WS-3, and rising towards the east corner of the Siltronic site adjacent to the Willamette River, where bedrock was encountered at a depth of 63 feet bgs at boring RP-1 (Figure 9).

6.2 Hydrogeologic Setting

Groundwater occurs in three principal hydrologic zones beneath the site, which from top to bottom include:

- the unconfined surficial fill WBZ,
- the semi-confined alluvial WBZ, and
- the confined bedrock aquifers in the CRBG.

6.2.1 Surficial Fill WBZ

As described in Section 6.1, the base of the surficial fill WBZ is typically defined by a fine grained alluvial silt unit. Although present across virtually the entire site, this silt unit becomes thin to locally absent approaching the shoreline at portions of the Siltronic and adjacent Gasco sites (Figure 8 and cross-section E-E', Appendix I), becoming thicker at the shoreline and riverward of the shoreline (cross-section A-A' and B-B'). The hydraulic conductivity of the silt unit at the Siltronic site, as determined from slug testing at well MW-3I, was previously calculated as 3.22×10^{-5} centimeters per second (cm/sec), indicating that the silt unit is not very conductive (Geraghty & Miller, 1991). The lack, or significantly attenuated, concentrations of COIs in groundwater beneath the silt unit across much of the Siltronic and Gasco properties (Section 6.5) supports the finding that the silt unit is of low conductivity, but as described later in this report, the silt unit does not completely confine the underlying alluvial WBZ across the entire site.

The saturated thickness of the surficial fill WBZ ranges from between 1 and 5 feet at locations adjacent to the river, to between 10 and 25 feet at the central and western portions of the site (cross-sections A-A', C-C', and I-I', Appendix I). Slug testing (Section 4.7) at the WS-8-33 and WS-9-34 locations (adjacent to the river) resulted in an estimated hydraulic conductivity for the surficial fill WBZ ranging from 2.3×10^{-4} to 5.4×10^{-4} cm/sec.

Based on observations made during push probe drilling activities related to the Focused RI, the occurrence of saturated conditions within the surficial fill unit at certain locations of the site appear seasonally dependent. Specifically, no saturated conditions were noted adjacent to the river within the surficial fill unit in August 2001 at boring locations P-6, P-7, or P-10, or at boring locations GP-4 through GP-7 in late September and early October 2002 (cross-section E-E', Appendix I).

As depicted on groundwater elevation maps (Appendix G), the overall groundwater flow direction across a majority of the Siltronic site within the surficial fill WBZ is northeast, toward the Willamette River. However, localized variability with regard to flow direction exists, most notably near the southern portion of the Siltronic property (WS-1 and WS-2 area), where an apparent groundwater divide is present within the fill. As depicted on the groundwater flow direction map from the April 2, 2002 area-wide event (Appendix G), groundwater south of the divide appears to flow to the south and southwest towards North Doane Lake and the southwest drainage ditch (North Doane Creek).

The horizontal hydraulic gradient within the surficial fill WBZ, as measured between wells WS-10-27 and WS-9-34 during the November 24, 2003 event is calculated to be approximately 0.017 (toward the river). The flow direction and gradient within the surficial fill WBZ at this portion of the site appears consistent through time.

A downward hydraulic gradient between the surficial fill WBZ and the alluvial WBZ is typical at the Siltronic and Gasco properties (Tables 4a and 4b), with a downward vertical gradient of between 0.025 and 0.042 measured at Siltronic between monitoring well WS-8-33 (fill unit) and WS-8-59 (upper alluvial unit) between August and November 2004. As such, groundwater in the surficial fill WBZ may be expected to migrate to the alluvial WBZ in areas where the underlying silt unit thins or otherwise does not impede downward flow. Based on COI distribution (Section 6.5.2.2), migration of petroleum constituents from the surficial fill WBZ to the alluvial WBZ has predominantly been limited to the northern corner of the Siltronic property (northern corner of the former 400 foot-wide lowland area) corresponding to areas where the DNAPL has migrated through the silt unit and into the alluvial WBZ.

Results of continuous short term water level monitoring within the surficial fill WBZ as depicted on hydrographs (Appendix F) did not identify a relationship between tidal fluctuations of the Willamette River and water levels within the surficial fill WBZ. However, long term, seasonal fluctuations in river level (Appendix H) were generally matched by similar longer term fluctuations of groundwater level within the surficial fill WBZ wells. The lack of tidal fluctuations of groundwater levels in the fill suggests isolation between the surficial fill WBZ, the river, and between the surficial fill WBZ and the alluvial WBZ (which does show tidal influence). The isolation may be a function of being perched above underlying silt as well as a degree of isolation with the river as a function of a thickening prism of shallow off-shore native silts located beyond the river embankment (cross-sections A-A', B-B', Appendix I).

6.2.2 Alluvial WBZ

The unconsolidated sands and silts of the alluvial WBZ across the Siltronic property range in thickness from approximately 2 to 25 feet near the west and central portions of the site, to approximately 175 feet near the northern corner of the site (see cross-sections A-A', C-C', and I-I', Appendix I). Although interbedded silts and sandy silts are present across various depth intervals within the alluvial WBZ, boring log data do not suggest the presence of separate hydrostratigraphic zones within the alluvial WBZ. Because monitoring wells are screened in various portions of the alluvial WBZ, for the purpose of groundwater flow evaluation, the alluvial WBZ has been arbitrarily subdivided into upper- (typically shallower than 100 feet bgs); intermediate- (typically 100 to 140 feet bgs); and lower-(typically greater than 140 feet bgs) intervals. As depicted on groundwater elevation maps (Appendix G), the overall groundwater flow direction within the alluvial WBZ across the Siltronic and adjacent Gasco sites is to the northeast, towards the Willamette River. Although the limited number and distribution of lower alluvial WBZ wells restricts the interpretation of flow direction within this zone, the groundwater potentiometric surface map for this depth interval (Appendix G), as well as the presence of COIs originating from the Rhone-Poulenc / Aventis project area to the south (Section 6.5), indicates that this zone may have more of a northerly component than the shallower alluvial zones.

Horizontal gradients for the upper alluvial WBZ depict a gradient of approximately 0.02 (toward the river) across the central portion of the Gasco/Siltronic properties during August 2004, as calculated between the MW-15-60 (Gasco) and WS-15-85 (Siltronic) locations. The horizontal gradient decreases substantially, with a minor reversal noted, within 400 feet of the river where a very flat, tidally influenced, gradient of 0.0002 (away from the river) was calculated between the WS-15-85 and WS-8-59 locations in August 2004. The estimated hydraulic conductivity (slug test) for the upper Alluvial WBZ ranges from 9.7×10^{-5} to 1.4×10^{-4} cm/sec at the WS-8-59 location.

Horizontal gradients within the intermediate-depth and lower portions of the alluvial WBZ as calculated for August 2004 were approximately 0.005 toward the river between WS-13-105 and WS-12-125 (intermediate), and 0.0004 toward the river between WS-15-140 and WS-11-161 (lower). Horizontal gradients and flow direction within the alluvial WBZ tend to be relatively consistent (e.g., same orders of magnitude) through time.

With regard to vertical gradients, a downward gradient ranging from 0.03 to 0.12 has been calculated between the upper-alluvial and intermediate-alluvial depth intervals at the WS-17 location, while a consistent -0.03 upward gradient has been identified at the WS-13 location. Upward vertical gradients tend to predominate between the lower and intermediate-depth intervals within the alluvial WBZ, with upward gradients of approximately -0.005 (WS-16 location) and -0.04 (WS-12 location) being relatively consistent through time, while vertical gradients at the WS-11 location tend to be an order of magnitude less and fluctuate between -0.0008 upwards and 0.0006 downwards (Table 4).

Based on the preceding, water levels collected from the Siltronic site suggest that the overall vertical groundwater gradient in the alluvium is predominantly downward within the upper portions of the alluvial WBZ, and upward across the lower portions of the alluvial WBZ (Table 4a), with the greatest horizontal gradient identified at locations further away from the river and at intermediate depths (e.g., 100 to 125 feet bgs) within the alluvial WBZ.

Results of continuous water level monitoring (Section 4.8), as depicted on hydrographs included within Appendix F, indicate the presence of a direct and rapid response to tidally-influenced changes in Willamette River elevation within the shoreline alluvial WBZ wells WS-8-59 (Siltronic), MW-4-57, and MW-4-101 (Gasco), while a similar, but subdued and delayed response to Willamette River tidal fluctuations was observed at a greater distance from the river in interior alluvial WBZ well MW-8-56 (Gasco). Specifically, the crest to crest time delay between peak river level and peak groundwater elevation at well WS-8-59 (adjacent to the shoreline) was approximately 15 to 30 minutes, while the delay at well MW-8-56 (250 feet upland from the shoreline) was approximately 4.5 hours. The preceding suggests hydraulic communication between the Willamette River and the alluvial WBZ, with river stage playing an important role with regard to groundwater transport, with brief periods of flow reversal observed at the peak of most high tide cycles.

A relatively thick (>10 foot) layer of silt is present in nearshore sediments adjacent to the Gasco and Siltronic sites, extending 200 to 300 feet from the shoreline (MFA 2005, Anchor 2004). It is expected that the fine-grained silt materials impede nearshore discharge of groundwater to the river from both the surficial fill and the upper portions of the alluvial unit.

Water levels measured offshore during the 2004 in-water investigation (MFA 2005) identified a predominant downward gradient throughout the alluvial WBZ beneath the Willamette River. These data suggest that the river near the Siltronic and Gasco properties may be a losing reach. Further, distribution of COIs between the upland portion of the site and the Willamette River (Section 6.5) provide evidence of a downward migration proximate to the river, suggesting that deeper groundwater in the area of Siltronic may be a component of a flow system with limited or no local discharge to the Willamette River.

6.3 Soil Testing Results

6.3.1 Surface Soils

The soils at all surface sample locations (S-1 through S-5) were found to consist of brown gravelly silty sand. No field screening evidence of potential impact (i.e., discoloration, suspect odor, or sheen) was observed at any surface soil sample location. All surface soil sampling locations (Figure 4) were well landscaped (grass ground-cover) with a lack of erosional features.

Results of laboratory analyses of surface soil samples, included on Tables 5 through 9, are summarized as follows:

- Total petroleum hydrocarbons were not identified at concentrations greater than method reporting levels at any surface soil sampling location.

- Total PAH concentrations ranging from 0.71 ppm to 2.14 ppm were identified in surface soils at locations S-1 through S-3, while no PAHs were identified at concentrations greater than method reporting levels at the S-4 and S-5 sampling locations. No SVOCs were identified at any surface soil sampling location with the exception of S-3, where 0.0707 ppm 2-chlorophenol and 0.077 ppm phenol were identified.

- Cyanide was not identified at concentrations greater than method reporting levels at any surface soil sampling location.

- With regard to metals, relatively consistent concentrations were identified at all sampling locations. Where possible, and as provided on Table 9, a comparison between identified soil concentrations and default background metals concentrations was conducted. The comparison was made utilizing DEQ default background concentrations for metals (DEQ 2002), and a Washington Department of Ecology (DOE) document entitled *Natural Background Soil Metals Concentrations in Washington State* (DOE 1994). Results of this comparison indicates that zinc, identified at a concentration of 104 ppm at the S-1 sample location, slightly exceeds the default background concentration of 86 ppm for this metal. No other metals concentrations were identified in surface soil samples at concentrations exceeding default background concentrations.

6.3.2 Stormwater Catch Basin Sample

Samples of accumulated soils / sludge within two process-area stormwater catch basins (CB2 and CB3) at the Siltronic property were collected and composited by representatives of Siltronic as described in Section 4.3. Results of laboratory analyses of the composited sample, included on Tables 5 through 9, are summarized as follows:

- 9,000 ppm oil-range petroleum hydrocarbons were identified in accumulated soils/sludge within the sampled catch basins. Further, 2.6 ppm total PAHs, 10 ppm toluene, and 0.4 ppm total cyanide were identified within these soils. No VOCs (other than toluene) or SVOCs (other than PAHs) were identified within these soils.

- With regard to metals, zinc was identified at a concentration of 360 ppm, exceeding the 86 ppm default background concentration for soil, while silver was identified at a concentration of 1.3 ppm, slightly exceeding the default background concentration of 1.0 ppm for soil.

6.3.3 River Embankment – Fab 2 Outfall Soil Sample

A soil sample (-173) from the embankment beneath the Fab 2 stormwater outfall was collected by HAI as described in Section 4.4. The soil sample, which was wet and contained a possible natural organic decay odor, displayed no field screening evidence of impact. Results of laboratory analyses of the sample, included on Tables 5 through 9, are summarized as follows:

- 3,720 ppm diesel-range petroleum hydrocarbons and 4,700 ppm oil-range petroleum hydrocarbons were identified in the soil sample. Further, 91.2 ppm total PAHs and 13,900 ppm total cyanide were identified within this soil sample. No VOCs, including benzene, or SVOCs (other than PAHs) were identified at concentrations greater than laboratory reporting levels.

- With regard to metals, a comparison of identified metals concentrations with default background concentrations was conducted (see Table 7). The comparison indicates that copper, lead, and zinc, identified at concentrations of 286 ppm, 31.7 ppm, and 846 ppm, respectively, were present at concentrations exceeding default background concentrations of 36 ppm, 17 ppm, and 86 ppm, respectively.

6.3.4 Subsurface Soils

Results of laboratory analyses of subsurface soil samples, included on Tables 5 through 9, are summarized as follows:

- PAHs and SVOCs: Soil samples with the greatest overall concentrations of petroleum-related contaminants directly correlate with zones where field screening evidence of impact (e.g., oil or tar presence) was identified (Table 5). With this regard, the greatest total PAH and SVOC concentrations identified in soil samples collected from shoreline borings were identified at a depth of 30 feet bgs at the P-1 boring location, correlating to a sample containing weathered tar. At this location, 35,432 ppm total PAHs were identified, as were 2,180 ppm 2-methylnaphthalene, 413 ppm carbazole, and 230 ppm dibenzofuran. The PAH concentrations identified at this location were approximately one order of magnitude higher than identified elsewhere, likely due to the fact that this sample consisted almost entirely of weathered tar (e.g., no soil). As described in Section 6.5.2, no detectable levels of benzene, and only low levels of PAHs, were identified in groundwater across this zone. Further, no SVOCs (e.g., 2 methylnaphthalene, carbazole, dibenzofuran) were identified in groundwater at the P-1 location.

- Benzene: The greatest overall benzene concentrations identified in soil as part of Focused RI activities (shoreline and interior borings) were on the west side of the Fab 1 structure, where 218 ppm benzene was identified in an oily sample collected from a depth of 20 feet bgs at the GP-10 location. As summarized on Table 5, the greatest benzene concentrations in soil were typically identified in samples containing visual evidence of oil or tar.

  With regard to near-shore areas, the greatest benzene concentration identified within shoreline borings was 8.63 ppm at a depth of 30 feet bgs in a tar-containing sample collected from the surficial fill at boring P-1.

- Cyanide: Detectable concentrations of total cyanide were identified in subsurface soils at concentrations ranging from 0.1 ppm to 15,000 ppm (Table 5). The greatest concentration of cyanide (15,000 ppm) was identified at a depth of 2 feet bgs at the P-8 boring location. The soil at this depth was described as brown silty sand containing a possible petroleum odor. No petroleum hydrocarbons were identified in this soil sample. No elevated metals concentrations, which would be an indicator of possible MGP-related spent oxide or purifier box wastes, were identified in this soil sample.

  Soils at locations with total cyanide concentrations greater than 1,000 ppm were all identified within the surficial fill unit and were described as sand with gravel, silty sand with gravel, or sandy silt with gravel. The elevated cyanide concentrations did not appear correlated with the presence or absence of field screening evidence of impact (i.e., tar or oil). No blue coloration (i.e., "prussian blue"), which is often typical of the presence of MGP-related spent oxide or purifier box wastes, was observed in any soil samples. No total cyanide concentrations greater than 16.4 ppm were identified within borings installed as part of LTI's investigation activities conducted at further upland locations (GP-02-01 through GP-02-03).

  One potential source for the identified cyanide impacts in soil would be spent oxide / purifier box wastes, should such materials have been incorporated into fill at the Siltronic property. However, imported fill is another potential source for the cyanide, especially since the greatest cyanide concentrations (greater than 1,000 ppm) were identified in fill at areas well away from the area where spent oxide was stored, and soils containing the highest cyanide concentrations did not contain field screening evidence of the presence of MGP-related materials (e.g., no wood chips, spent lime, prussian blue coloration, tar or oil). Further, the maximum total cyanide concentrations identified in the fill materials at the Siltronic property (up to 15,000 ppm) do not correlate with concentrations identified in soils at the adjacent Gasco site, where cyanide impacts likely attributable to spent oxide / gas purifier wastes have been identified at concentrations of no greater than 518 ppm.

- Metals: With regard to metals, relatively consistent concentrations were identified at all sampling locations. Where possible, and as provided on Table 9, a comparison between identified soil concentrations and default background metals concentrations was conducted. The preceding indicated the presence of five metals at concentrations exceeding default background concentrations at the P-2, P-4, P-9, and P-10 boring locations. Specifically, cadmium, copper, lead, nickel, and zinc were elevated above default background values at the P-2 boring location, while lead and zinc were both elevated above default background values at the P-4 and P-9 boring locations, and lead was elevated above default background values at the P-10 boring location.

6.4 Oil and Tar Observations

With regard to field screening or observation of subsurface soils, references to bitumen, tar, or oil were noted on geotechnical soil boring logs for borings installed at the site in 1977, prior to Siltronic's purchase of the property. Further, oil and tar have reportedly been identified by Siltronic personnel within the surficial fill unit during development activities associated with the Siltronic property (Section 3.5.2), and have been further identified within the surficial fill unit, and in a more limited area (i.e., the northern corner of the property) oil has been observed within the alluvial unit at the site.

A summary and description of all borings at the Siltronic site where visual occurrence of oil or tar has been noted within subsurface soil logs is included in Table 19. This table was prepared based on HAI's review of boring logs. Also, cross-sections for the subject property (Appendix I) depict locations and depth intervals where oily or tarry soils have been identified at the site, with cross-sections A-A' through C-C' extending to in-water borings installed beneath the river near the northern corner of the property by MFA in October 2004 (MFA, 2005).

Figures 10 through 12 depict the estimated extent of tarry or oily (NAPL) soils across different subsurface horizons at the Siltronic property based on boring log descriptions (Table 19), interpretation between boring locations, and descriptions provided by site personnel. Specifically, Figure 10 depicts the estimated lateral extent of oily and tarry soils within the surficial fill unit;

Figure 11 depicts locations where oily soils or DNAPL have been identified in borings or wells within the underlying alluvial WBZ at any depth shallower than 100 feet bgs; and Figure 12 depicts locations where oily soils or DNAPL have been identified at any depth within the alluvial WBZ greater than 100 feet bgs. Because the base of the river is at a depth of approximately 80 feet bgs (relative to the surface at Siltronic), the DNAPL as identified in Figure 12 (i.e., greater than 100 feet bgs) does not have a complete exposure pathway to the river.

With regard to the presence of DNAPL in monitoring wells at the Siltronic property, DNAPL (oil) has been identified within one surficial fill WBZ well, located at the north central portion of the Siltronic site (WS-10-27). This well is located approximately 900 feet upland from the Willamette River shoreline. Thickness of DNAPL accumulation in this well is approximately 1 to 2 feet.

With regard to DNAPL penetration into the alluvial WBZ (Figure 11), oil has been observed at the Siltronic site within soils collected from beneath the silt unit at borings B-1-8, WS-11, WS-14, WS-15, and WS-16, all in the former 400-foot wide lowland area located at the northern end of the current Siltronic property.

The deepest NAPL directly observed on Siltronic property has been identified in the 400 foot-wide former lowland area at borings B-1-8 and WS-16, where NAPL has been logged to depths of up to 74 feet bgs (WS-16).

In 2004, MFA identified DNAPL near the northern corner of the Siltronic property at nearshore well locations WS-11-125 and WS-14-125. Based on screened intervals for the wells, the DNAPL identified at these locations (0.5 to 3 feet at the base of each well) would be present across some fraction of the depth range between 110 and 125 feet bgs. Further, MFA identified approximately 6 feet of DNAPL within well WS-15-85, an 85 foot deep alluvial WBZ well located further upland from the WS-11-125 and WS-15-125 locations, within the former lowland area (McClincy, Pers. Comm., 2005).

Neither DNAPL, or elevated petroleum-related COI concentrations have been identified in wells screened across depths of 145 to 160 feet at either the WS-11 or WS-14 locations, or across depths of 125 to 140 feet bgs at the WS-15 location.

The identification of DNAPL within alluvial WBZ within wells constructed at the northern portion of the Siltronic property supports the conceptual model of NAPL penetration beneath portions of the former lowland area near the northern corner of the Siltronic property (Figures 11 and 12). The depth of the NAPL identified at the WS-11-125 and WS-14-125 locations, which are proximate to the river embankment (Figure 12), indicate it to be present across a zone that is below the base of the river, and it therefore is not likely to migrate to the river (cross-section E-E', Appendix I). NAPL was not observed in push probe borings installed by Siltronic off-shore of this area, except as limited to near surface / shallow sediments (Table 19), which would appear to have been directly placed onto the sediments.

Analytical testing of the oily DNAPL recovered from well WS-11-125 was conducted by Siltronic in 2004. Results of this testing indicates the DNAPL has a specific gravity of 1.09, is primarily composed of diesel-range hydrocarbons (593,000 ppm), and contains a high fraction of PAHs, with naphthalene having the highest concentration (68,000 ppm). Additionally, carbazole (1,340 ppm), dibenzofuran (858 ppm), and TCE (59.6 ppm) were identified in the DNAPL, as was 271 ppm benzene (MFA, 2004). The TCE is apparently present as a function of the commingling of the heavy oil occurrence with the Siltronic TCE occurrence. TCE, a solvent, may be expected to entrain or otherwise increase dissolution and mobility of DNAPL in areas where commingling occurs.

Based on the preceding, it appears that the DNAPL (oil) below the silt unit at the Siltronic property is attributable to a source within the former 400 foot-wide lowland area. As previously described, petroleum wastes may have overflowed from the Gasco effluent ponds to the former ground (e.g., silt unit) surface between 1951 and 1956, with NAPL subsequently migrating vertically into the alluvial WBZ through rootlet zones within the silt unit beneath the northern portion of the lowland area (Figures 11 and 12, and cross-Section A-A' in Appendix I). The greatest vertical DNAPL penetration appears to have occurred proximate to an area where the silt surface is found to thin (WS-15/B-1-8 area), and where the greatest TCE concentrations are present.

With regard to other shoreline area borings at the Siltronic site, borings P-1, P-4, P-5, P-7, GP02-01, and GP-02-02 identified the presence of thin (0.5 to 1.5 feet thick) zones of weathered tar or oil within the fill (Figure 10). At borings P-1, GP02-01, and GP02-02, the weathered tar or oil was identified at the base of the fill, on what was likely the pre-fill ground surface. As such, this tar or oil is likely attributable to former effluent pond overflows or direct placement.

Oily soil identified at the P-7 location correlates with the area of possible discolored soils, as identified in 1970 aerial photograph of the site, as being present in the immediate vicinity of the former Western Transportation structures (Figure 3). The low concentrations of PAHs in the oily soil identified at P-7 (total PAHs are less than 2 percent of the TPH), as well as its location relative to the suspected historical surface staining, suggest that the impacts at this location are likely diesel or fuel oil related, and appear to be associated with the former Western Transportation fueling operations. At the P-4 and P-5 boring locations, the oil / tar was found mixed within the sand or sand and gravel fill, and did not correlate with the former ground surface. At the P-5 location the tarry zone correlated with the presence of brick fragments. Based on these observations, it appears that the oil and tar identified at borings P-4 and P-5 is a function of incorporation of oil and tar into the fill during placement (1966-1975). Due to the nature of this source (mixing into fill), it is possible that other discontinuous zones of oil or tar may exist throughout this portion of the site.

In addition to the preceding, as depicted on Figure 10, oil has been identified within the fill unit elsewhere at the Siltronic property. Specifically, borings located at the undeveloped southern corner of the site have identified the presence of oily soils within the fill, with observations of oil identified below a depth of 10 feet bgs, with the thickness of oily zones ranging from 1 foot or less (WS-6, B-6, B-102), to up to 10 feet (WS-1, WS-2).

Data concerning the presence or absence of tar or oily soils are not available for the portion of the site east of the Olympic pipeline in the parking / undeveloped portion of the site. Based on review of historical aerial photographs, and based on observations of fill at other portions of the site, it is possible that fill placed at this portion of the site also may contain tar and/or oil, which, if present, would have been incorporated into the fill in this area during the 1966 to 1975 timeframe.

With regard to the DNAPL identified at shoreline wells WS-14-125 (cross-section A-A') and WS-11-125 (cross-section B-B'), direct observations of soil core indicate these areas to be wholly disconnected and separate relative to the shallow oily sediments identified at off-shore locations. Specifically, borings installed offshore of WS-11 and WS-14 through the entire thickness of the alluvial unit did not identify the presence of DNAPL across horizons that would be indicative of subsurface transport. Further, due to the depth of the DNAPL (greater than 100 feet bgs); the density of the DNAPL (greater than 1.0); and the apparent presence of a downward hydraulic gradient beneath the river, the DNAPL does not appear to be a future migration threat with regard to the river.

Based on the preceding, the oily sediments off-shore of the northern portion of Siltronic are likely the result of direct discharges from the former Gasco effluent ponds via the former ditch located near the current Gasco / Siltronic property boundary (1941 to 1951) or direct discharges from the former 400-foot wide lowland area at the Siltronic property via the ditch formerly located approximately 400 feet upriver from the property boundary (1951 to 1956), rather than through the erosion of bank or surface soils. or the migration of contaminated groundwater or NAPL to surface water.

6.5 Water Sampling Results

6.5.1 Stormwater – Fab 1, Fab 2, and Administration Building Outfalls

Stormwater samples from the Fab 1 outfall sampling point, and from the end of pipe at the Fab 2 and Administration Building outfalls, were collected by HAI as described in Section 4.4. Results of laboratory analyses of the samples, included on Table 10, are summarized as follows:

- Benzene, PAHs, SVOCs, and cyanide were not identified in stormwater samples collected from any of the three outfalls. With regard to detected VOCs, acetone [34.4 parts per billion (ppb)] and chloroform (2.69 ppb) were both identified in the stormwater sample collected at the Fab 1 sampling outfall.

- Metals, which are naturally-occurring in the environment, were identified in unfiltered water samples collected from all three stormwater outfall sampling locations. Specifically, the metals barium, copper, iron, magnesium, manganese, titanium, vanadium, and zinc were identified at all sample locations, while lead was identified only at the Administrative Building outfall.

6.5.2 Groundwater

Results of groundwater sampling activities conducted as part of NW Natural's Focused RI activities at the Siltronic site are described herein. Siltronic's investigations into chlorinated solvent impacts at the site are described in reports submitted to DEQ separately by Siltronic and are not summarized here.

Results of all identified and available laboratory analyses of groundwater samples collected from monitoring wells and temporary well points at the Siltronic property are summarized on Tables 11 through 18. The most recent available data for the Siltronic site, as summarized on these Tables, were used to prepare contaminant plume maps for key COIs [benzene (Figures 13 and 14), naphthalene (Figures 15 and 16), and total cyanide (Figures 17 and 18)] within both the surficial fill and alluvial WBZs.

Groundwater quality data from the Siltronic property that are posted on the referenced figures were obtained from results of investigatory activities conducted by HAI for NW Natural, and LTI, MFA, and others for Siltronic. Primary sources for the Siltronic property data include a 2003 HAI report (HAI, 2003), as well as reports prepared by MFA (MFA 2003, 2004a,b, 2005), and a 1990 report prepared by CH2M HILL, Inc. (CH2M HILL, 1990). Further, the most recently available groundwater quality data for each monitoring point at the adjacent Gasco site (HAI, 2005), and recently obtained groundwater quality data from temporary well points installed beneath the Willamette River near the northern corner of the Siltronic property (MFA, 2005), were used in preparation of these plume maps. The Siltronic property data are summarized herein on Tables 11 through 18.

Hydrogeological cross-sections included within Appendices I and J depict groundwater sampling intervals, location of identified mixed tar or oily soils, as well as benzene concentrations (Appendix I) or naphthalene concentrations (Appendix J), with plume contours depicting the interpreted extent of impact.

Descriptions of the distribution of key COIs, selected as key indicators relative to the distribution of all COIs, are provided in the following sections.

6.5.2.1 Surficial Fill WBZ

Benzene

As depicted on Figure 13, the highest concentrations of benzene within the surficial fill WBZ at the Siltronic property are identified beneath the western portion of the site (Olympic Pipeline release area), where up to 25,000 ppb were identified (GP-24).

The distribution of benzene within the surficial fill WBZ (Figure 13) suggests that both the Olympic Pipeline and MGP-residues may be sources of benzene impact at Siltronic, with commingling occurring as a function of the benzene plume from the Olympic release migrating across an area containing historically placed MGP wastes within the 400 foot lowland area.

With regard to nearshore wells, benzene concentrations in the surficial fill WBZ are less than 50 ppb across a majority of the Siltronic site and across all of the Gasco site (Figure 13). Specifically, benzene concentrations greater than 50 ppb are limited to approximately 400 feet of shoreline immediately upriver of the Siltronic/Gasco property line (e.g., the former lowland area), where concentrations of between 61.2 ppb (boring P-2) and 104 ppb (boring P-3) have been identified. Cross-sections A-A' through E-E' (Appendix I) depict the extent of benzene concentrations in groundwater within the surficial fill adjacent to the Willamette river.

As depicted on these cross-sections, and as depicted on Figures 13 and 14, with regard to the Siltronic property, vertical migration of benzene from the surficial fill WBZ through the silt unit and to the underlying alluvial WBZ is limited to the northern corner of the Siltronic property.

With regard to the areas proximate to North Doane Creek (i.e., southern and southwestern portions of the Siltronic property), with the exception of one location (WS-6), concentrations attenuate from the apparent source areas, with no benzene concentrations greater than 50 ppb being identified within the surficial fill WBZ at inferred down-gradient locations. With regard to the sample collected from well WS-6, located near the southern corner of the property, 614 ppb benzene was identified in groundwater. Shallow groundwater in this area may discharge to North Doane Creek, which in turn discharges to the Willamette River at the City Outfall 22C location. Outfall

22C is the discharge point for 1,008 acres of drainage that includes several industrial properties, city streets and other transportation right-of-ways. Cross-sections G-G' through I-I' (Appendix I) depict identified benzene concentrations in groundwater across this portion of the site.

Naphthalene

The distribution of naphthalene in the surficial WBZ is similar to that described above for benzene, with the exception that the areas of highest concentration are shifted northeast, corresponding to a low area on the top of the silt unit at the former 400 foot wide lowland area at the Siltronic site (495,000 ppb at GP-22)(Figure 15). Based on the preceding, a primary source for the naphthalene in groundwater at Siltronic appears to be oily soils present within the former lowland area. Cross-section G-G' (Appendix J) depicts naphthalene concentrations in groundwater parallel to the river across Siltronic and a portion of the adjacent Gasco site at a location proximate to the suspected source areas.

No naphthalene concentrations greater than 500 ppb have been identified within the surficial fill at any shoreline locations at either the Siltronic or the adjacent Gasco site. Cross-sections A-A' through E-E' (Appendix J) depict the extent of naphthalene concentrations in groundwater within the surficial fill adjacent to Willamette river bathymetry. As with benzene, described above, and with regard to the Siltronic property, vertical migration of naphthalene impacts from the surficial fill WBZ through the silt unit and to the underlying alluvial WBZ is primarily limited to the northern corner of the Siltronic property. With regard to the southern portion of the site, up to 2,100 ppb naphthalene have been identified within the surficial fill WBZ (WS-6 well location), with the patchy zones of oil identified within fill in this area (Figure 10) apparently acting as a source for lower level impacts to shallow groundwater. Shallow groundwater in this area may discharge to North Doane Creek, which in turn discharges to the Willamette River at the City Outfall 22C location. Outfall 22C is the discharge point for 1,008 acres of drainage that includes several industrial properties, city streets and other transportation right-of-ways. Cross-sections G-G' through I-I' (Appendix J) include identified naphthalene concentrations (and the relationship to identified oily soils) in groundwater across this portion of the site.

Cyanide

Concentrations of total cyanide greater than 0.05 ppm are present in the surficial fill WBZ across a majority of the Siltronic site (Figure 17), with the highest concentrations being identified at the northern portion of the Siltronic site south of the former lowland area (4.41 ppm at GP-2-01).

At shoreline locations, the greatest concentrations of cyanide (greater than 0.5 ppm) were limited to within the 400 feet of shoreline immediately upriver of the Siltronic/Gasco property line where concentrations of up to 0.726 ppm have been identified (well WS-8-33). As described in Section 6.3.4, the source(s) for the identified cyanide appear to be related to the surficial fill, but are otherwise not well understood.

Other Chemicals

With regard to VOCs, low levels of styrene (up to 7 ppb at the WS-10-27 location), trimethylbenzene isomers (up to 156 ppb at the GP-24 location), as well as low levels of butylbenzenes, propylbenzenes, and 1,2-dichloroethane were identified sporadically in groundwater samples collected from the surficial fill WBZ at the northern portion of the Siltronic property. With exception of styrene, these organic compounds are common components of petroleum and their presence in groundwater impacted with benzene or naphthalene, as described above, is typical. Styrene, although manufactured from a petroleum source, is used as a component of plastics, rubber, latex, and polyester resins. The source of the low level styrene detections identified sporadically at the site is not known.

Certain SVOCs, including several phthalates, carbazole, dibenzofuran, and 2-methylnaphthalene, were identified in groundwater collected from shore-line push probe sample locations P-1, P-2, P-3, P-5, P-8, P-9, and GP-4, with the greatest nearshore concentrations identified within the surficial fill WBZ at the P-3 / WS-8-33 location. Specifically, with regard to monitoring well WS-8-33, concentrations of carbazole (18.3 ppb), dibenzofuran (3.05 ppb), and 2-methylnaphthalene (41.9 ppb) were identified during the final sampling event conducted in July 2003, while no SVOCs were identified at the WS-9-34 location. Further upland from the shoreline, within the former 400-foot wide lowland area, the greatest detected concentrations of carbazole, dibenzofuran, and 2-methylnaphthalene were 338 ppb, 25.2 ppb, and 510 ppb, respectively (WS-10-27). The identified SVOCs are COIs with regard to oil and tar, and their presence, especially at locations such as WS-10-27, completed within oily soils, is expected.

The low level detection of these constituents does not appear to represent a unique source or distribution relative to the depicted benzene and naphthalene plumes, so further discussion of these constituents are not included herein.

6.5.2.2 Alluvial WBZ

Benzene

With regard to the alluvial WBZ, as depicted on Figure 14, benzene impacts greater than 50 ppb are limited to the northern corner of the Siltronic property (i.e., former lowland area) and the eastern corner of the adjacent Gasco property (former effluent pond / discharge area). Because only very low concentrations of benzene were detected in vertical groundwater quality profiling at the B-56 location at the Gasco shoreline, it appears that there are two separate areas of contaminant entry through the upper silt unit into the alluvial WBZ. Of these two areas, one appears to have been a source to relatively shallow impacts as identified in a downriver direction from boring B-56 at Gasco (e.g., MW-4-56 and MW-16-45 well locations), while the other appears to have resulted in deeper impacts as identified near the eastern corner of Gasco (MW-5-100) and extending in an upriver direction across the northern portion of the Siltronic property (e.g., WS-14-125 and WS-11-125 well locations).

With regard to Siltronic, the deeper benzene plume extends along the shoreline from a location proximate to the Gasco/Siltronic property boundary (well MW-5-100 at Gasco), approximately 375 to 450 feet upstream to a location on the Siltronic property between the WS-11-125 and WS-12-125 well locations (cross-section E-E', Appendix I). Vertically, benzene concentrations greater than 50 ppb at the shoreline along the Siltronic property extend from between approximately 60 to 70 feet bgs to approximately 140 feet bgs (cross-section A-A', Appendix I).

Within this plume, the greatest benzene concentrations are identified at depths greater than 80 feet bgs at the shoreline proximate to the Siltronic /

Gasco property line, where 11,500 ppb have been identified in groundwater from 90 to 100 feet bgs at well MW-5-100 (Gasco), and 8,200 ppb have been identified at 86 feet bgs at the adjacent WS-14 location (Siltronic). Laterally, this plume attenuates significantly over a short distance with a maximum of 3.62 ppb identified in a downriver direction from MW-5 along the shoreline at the B-56 location, and with a maximum of 536 ppb identified immediately upstream of WS-14 along the shoreline at the WS-11 well cluster location. The extent of the plume is further delineated upstream along the shoreline at the WS-12 well cluster location, where benzene concentrations across all zones have typically been non-detect to less than 20 ppb, although the November 2004 sampling result at this location (Table 15) indicated the presence of 446 ppb benzene across a depth interval of 145 to 160 feet bgs. Because the previous three sampling events at this location, as well as temporary well point data from across this depth interval (Table 13) indicate less than 0.6 ppb benzene, this most recent result appears anomalous.

This deeper plume, which extends from the eastern corner of the Gasco site approximately 400 feet across the Siltronic property line (e.g., MW-5, WS-14, and WS-11), appears to be the result of deeper DNAPL migration near the northern limit of the former effluent ponds in vicinity of the Gasco/Siltronic property boundary (e.g., borings B-32 / B35) and/or within the former 400 foot wide lowland area (B-1-8 / WS-15-85). Cross-sections A-A’ through G-G’ within Appendix I depict the vertical profile of the plume, including inferred location of where DNAPL and associated dissolved phase impacts have penetrated into the alluvial WBZ, based on available soil descriptions and groundwater quality data.

Results from in-river boring work conducted by MFA for Siltronic (borings GP-25 through GP-32) indicate that the benzene plume has not moved upward to shallow sediments beneath the river within the area of investigation (cross-section A-A’ through C-C’, Appendix I). The few locations where shallow benzene concentrations exceed 50 ppb (99.2 ppb at GP-27, 103 ppb at GP-32), appear to be related to the presence of oily and/or tarry zones within sediments coinciding with the sample locations.

The lack of upward plume migration is supported by MFA’s findings that a downward hydraulic gradient predominates below the river, and that this section of river may predominantly be a losing reach (MFA, 2005). Laterally, the benzene plume is defined in the upriver direction. To the north, in the apparent down-gradient direction, the plume appears to extend towards a location off-shore of the adjacent Gasco site, with the apparent down-gradient extent not fully delineated.

Naphthalene

The distribution of naphthalene within the alluvial WBZ closely matches the vertical and lateral distribution of benzene as described above, with concentrations greater than 500 ppb extending across the northernmost 300 feet of shoreline at Siltronic, and across a depth interval of 60 to 150 feet bgs. Similarly, areas of naphthalene migration into the alluvial WBZ from the overlying surficial fill WBZ appear to coincide to areas where benzene migration has occurred, being limited to the northern corner of the Siltronic site, and eastern corner of the Gasco site (cross-section A-A' through G-G', Appendix J).

As with benzene, results of MFA in-water work (MFA 2005) suggest that the upland-sourced naphthalene plume is migrating beneath the river without discharge to shallow river sediments (cross-section A-A' and B-B', Appendix J). However, as further depicted on cross-section B-B' and on Figure 16, it appears that historical direct deposition impacts to sediments offshore of the Siltronic site (e.g., as observed in borings GP-27 and GP-29) may be acting as an independent source of contaminants to surface porewater and deeper groundwater, with the highest concentrations identified from 0 to 2 feet below mudline and decreasing with depth through the entire thickness of the alluvial WBZ. Such a concentration profile is entirely consistent with impacts from the surface placement of material and inconsistent with a plume coming from dissolved phase transport from the uplands (in which case the concentration gradient would be the reverse of what is observed). As with benzene, the plume as it extends beneath the river is delineated in the upriver direction, but the down-gradient extent (to the north and offshore of the Gasco site) has not been defined.

Cyanide

With regard to data available in proximity to the river (Figure 18), cyanide concentrations greater than 0.5 ppm have been identified near the northern corner of the Siltronic property.. Vertically, cyanide concentrations greater than 0.5 ppm have been identified within the alluvial WBZ at Siltronic to depths of approximately 100 feet bgs (e.g., GP-4, GP-6, P-3), while concentrations greater than 0.05 ppm have been identified to the base of the alluvial WBZ (e.g., WS-15 and WS-16).

As depicted on Figure 18, the greatest total cyanide concentrations identified in the alluvial WBZ at the Siltronic site were identified at a location corresponding to the highest concentrations identified in the surficial fill WBZ (Figure 17). Specifically, 1.01 ppm cyanide was identified in the upper alluvial WBZ at the GP-2-01 location (54-58 feet bgs), while 4.04 ppm total cyanide was detected in the overlying surficial fill WBZ at this location.

As described in Section 6.3.4, the source(s) for the identified cyanide appear to be related to the surficial fill, but are otherwise not well understood.

Other Chemicals

Methyl-tert-butyl-ethane (MTBE), chlorobenzenes, and dichlorobenzenes (and at certain locations low levels of benzene and TCE), 2,4,5-TP (silvex), and chloroform, COIs relative to site investigation activities occurring on the Rhone-Poulenc / Aventis property to the south of Siltronic (AMEC, 2003), were identified in groundwater samples collected from within the Alluvial WBZ both at the southern portion of the property (e.g., wells GP-11, RP-1-51, RP-1-65, RP-6-87, RP-7-84, RP-7-119, as well as at the northern portion of the Siltronic property (WS-11 through WS-17). The identification of the off-site COIs at the northern portion of the Siltronic property were all identified near the basal portion of the alluvial WBZ, typically well below the petroleum or chlorinated solvent-related impacts derived from sources located at the northern portion of the Siltronic property. The presence of these off-site southward originating COIs near the northern corner of the site, supports the general flow direction interpretation for the basal alluvial WBZ, which depicts a more northerly component of flow than within the upper portions of the alluvial WBZ.

PCE has been identified at a low concentration within the alluvial WBZ in a sample collected from the WS-13-69 well location (3.26 ppb), and within a sample collected at a depth of 80 feet bgs from the boring for well WS-15 (0.87 ppb). PCE is not a COI with respect to known potential sources of impact at Siltronic or the adjacent Gasco site. Although the source of the PCE is not known, locations where it was identified had significant concentrations of TCE (e.g., 198,000 ppb at WS-13-69 and 243,000 ppb at WS-15). The coincidence of these two chlorinated solvent constituents would suggest that the low level PCE concentrations are possibly present as the result of impurities within the TCE, as opposed to the presence of a unique on-site or off-site source.

7.0 SUMMARY OF FINDINGS

The primary objective of the Phase I Site Characterization Report is to present the findings of investigatory work conducted at the Siltronic site to date, including updates to the conceptual site mode, in order to support a source control evaluation with regard to contaminant migration from the Siltronic property to the Willamette River.

The source control evaluation, to be provided as a separate stand-alone document, will evaluate and identify the need to implement source control measures at the Siltronic site, and/or will identify those specific areas where additional investigatory activities are necessary to more completely evaluate the potential that unacceptable levels of hazardous substances may be discharging from the Siltronic site to Willamette River sediments.

A brief summary of the findings, including contaminant source areas and pathways of significance with regard to potential sources of impact to the Willamette River from the Siltronic site, is provided below, as is a preliminary identification of additional data needs – to be refined upon completion of the source control evaluation update.

7.1 Contaminant Sources

7.1.1 Sources Attributable to MGP-Related Waste Management

PG&C operated an oil MGP on the Gasco property, north of Siltronic, from 1912 until 1956. PG&C owned a portion of the Siltronic property from 1939 until 1962, during which time waste management activities were conducted at three portions of the present-day Siltronic property, as follows:

Former 400-foot Wide Lowland Area: Immediately south of the common Siltronic/Gasco property line. This approximate 10-acre area received tar and tar/oil/water emulsifications from effluent pond overflow and from direct placement of MGP residuals between 1941 and 1956. Soil and groundwater impacts attributable to this feature are present at the Siltronic site. Estimates based on tar thickness measurements made in 1960 (2 to 6 feet of tar across much of the area) indicate approximately 40,000 cubic yards of tarry materials may have been present in this area subsequent to cessation of all MGP-related activities at the Gasco site, which occurred in 1956. The function of this lowland area was to minimize effluent discharges to the Willamette River. COIs related to this area include PAHs, SVOCs, and monoaromatic hydrocarbons (e.g., benzene).

Former Depression or Excavation**:** South of the former lowland area, approximately 2 to 3 feet of tar was identified at the base of this approximate 0.5-acre apparent excavation when evaluated in 1960. This feature was first observed in aerial photographs dated 1955. Estimates based on tar thickness measurements made in 1960 indicate approximately 2,000 cubic yards of tarry materials may have been present in this area subsequent to cessation of all MGP-related activities at the Gasco site. The function of this depression / excavation is unknown. COIs related to this area include PAHs, SVOCs, and monoaromatic hydrocarbons.

Former Spent Oxide / Gas Purifier Waste Storage Pile: Company records indicate an estimated 34,000 cubic yard stockpile of spent oxide / gas purification wastes were formerly stored immediately south of the common Siltronic/Gasco property line near the western corner of the Siltronic property. Aerial photographs indicate the stockpile was present at this location between 1952 and 1966, several years after NW Natural sold the property. The final disposition of this material is unknown. COIs potentially related to this these materials include cyanide and metals (arsenic, chromium, copper, lead, nickel, zinc).

7.1.2 Other Contaminant Sources

Olympic Pipeline Petroleum Release(s): The Olympic Pipeline utilizes two product lines (diesel and kerosene; gasoline) within a utility corridor that traverses the central portion of the Siltronic property. Line failure resulting in product release and soil and groundwater impacts was identified near the western corner of the Siltronic facility in 1979, proximate to the 400-foot wide former lowland area. COIs related to this area includes PAHs and monoaromatic hydrocarbons.

Western Transportation Petroleum Release(s): Western Transportation operated a petroleum fueling dock at the eastern corner of the Siltronic between approximately 1930 and 1950. Possible surface staining was noted on a 1970 aerial photograph, and petroleum impacts to soil, likely attributable to these activities, have been identified. COIs related to this area includes PAHs and monoaromatic hydrocarbons.

Siltronic-Related Releases: TCE leaked from an underground storage tank system operated by Siltronic at the northern portion of the property resulting in soil and groundwater impacts. Related COIs include: TCE and degradation products; possibly tetrachloroethene (PCE) as an impurity within TCE. Other releases associated with Siltronic operations (1980-1997), also on the northern portion of the property, include chromium solution, acids, caustics, and organic wastewater releases or spills.

Off-Site Releases: Contaminants related to identified sources south of the Siltronic property have been detected within groundwater at the Siltronic site, indicative of on-site migration. Off-site contaminants include: benzene, chlorobenzene isomers, dichlorobenzene isomers, MTBE, 2,4,5-TP, chloroform, TCE and degradation products.

Filling Activities: Site filling activities were conducted on the Siltronic property between 1967 and 1975. Filling involved placement of 1.5 million cubic yards of material on the property, including approximately 700,000 cubic yards of dredge spoils from unidentified locations. Depending upon origin, dredged sediments could reasonably have been impacted by many different sources of potential contamination, including ship traffic, industrial operations (such as MGP, wood treating facilities, shipyards, pesticide manufacturing, or petroleum terminals), agricultural activities, or urban run-off. During the time of filling activities, the property was owned by Mr. Victor Rosenfeld and Mr. H.A. Anderson.

In addition to possible sources of impact from the dredged sediments used as fill, observations of tar or oil during various investigations or construction activities at the Siltronic site, as well as dark soils visible in aerial photographs between 1967 and 1971, suggest the possibility that MGP-related wastes from the 400-foot wide lowland area may have been redistributed and combined with fill placed at various portions of the Siltronic property during filling activities (1966-1975), after NW Natural sold the property in 1962.

7.2 Hydrogeologic Framework

Groundwater occurs in three hydrologic zones beneath the Siltronic site, the unconfined surficial fill WBZ, the semi-confined alluvial WBZ, and the confined bedrock aquifers of the Columbia River Basalt Group.

Surficial fill consists of 700,000 cubic yards of dredge materials and 800,000 cubic yards of other materials. Impacted soils, derived from the emplaced dredge or other imported fill and/or from re-distribution of impacted soils/residues from former MGP-related waste management areas, have been identified within the surficial fill at numerous locations across the property.

The saturated thickness of the surficial fill WBZ ranges from 1 to 5 feet adjacent to the river, to between 10 and 20 feet across the central, southern, and western portions of the site. Overall groundwater flow direction across a majority of the site is to the northeast, towards the Willamette River. A groundwater divide exists near the southern and western portions of the site, with flow back to the south and toward North Doane Creek.

Responses to tidal fluctuations in the adjacent Willamette River are not expressed in the surficial fill WBZ, indicating this zone is isolated from the river. A downward hydraulic gradient between the surficial fill WBZ and the alluvial WBZ is typical. As such, groundwater in the surficial WBZ may migrate to the alluvial WBZ in areas where the intervening silt unit thins or otherwise does not impede downward flow.

Beneath the surficial fill WBZ, and defining the surface of the alluvial unit, is a laterally extensive fine-grained silt unit. The silt unit beneath the Siltronic site has been found to range in thickness from approximately 70 feet near the central portion of the site, thinning toward the river, where thicknesses of 1 to 3 feet are common at the riverbank. Beyond the riverbank, a thickening prism of silt has been identified. Vertical migration of groundwater through the silt unit has occurred at the northern portion of the Siltronic site (400-foot wide former lowland area), where the silt unit becomes thin, or where the presence of rootlet zones has allowed fingering of NAPL through the silt.

The alluvial WBZ consists of interbedded sands and silts underlying the silt unit, and ranges in thickness from 2 to 25 feet thick at the central and western portions of the site, to up to 175 feet near the northern corner of the site. Overall groundwater flow direction in the alluvial WBZ is to the northeast toward the Willamette River, although a more northern component of flow is apparent at the basal portions of the alluvial WBZ.

The overall vertical gradient in the alluvium is predominantly downward in the upper portions of the alluvial WBZ, and upward across the lower portions of the alluvial WBZ, with the greatest horizontal gradient identified at locations further away from the river and at intermediate depths (e.g. 100 to 125 feet bgs).

A relatively thick (>10 foot) layer of silt is present in nearshore sediments adjacent to the Gasco and Siltronic sites, extending 200 to 300 feet from the shoreline. It is expected that the fine-grained silt materials impede nearshore discharge of groundwater to the river from both the surficial fill and the upper portions of the alluvial unit.

Water levels measured in offshore well points identified a predominant downward gradient throughout the alluvial WBZ beneath the Willamette River, indicating the river near the Siltronic and Gasco properties may be a losing reach.

Available vertical gradient data and contaminant concentration profiles adjacent to and beneath the Willamette River are not suggestive of the discharge of groundwater from intermediate to deep portions of the alluvial WBZ to Willamette River sediments.

7.3 Groundwater Quality

Oil and tar historically placed within the former lowland area as a result of effluent pond clean-out and overflow are a source area for identified aromatic hydrocarbon, PAH, and SVOC impacts identified within the fill and alluvial WBZs beneath the 400-foot wide lowland area, with a sharp decline in contaminant concentrations to the south, beyond the limit of the former lowland area. Additionally, the Olympic Pipeline release area is present within this portion of the site, and appears likely to be contributing to the identified benzene concentrations in groundwater.

The benzene plume extends to the Willamette River shoreline within the surficial fill WBZ only near the northern corner of the Siltronic site (down-gradient from the former lowland area), and then only at low concentrations (up to 104 ppb). The naphthalene plume does not extend to the Willamette River shoreline within the surficial fill WBZ at any location.

Vertical migration of petroleum hydrocarbon-related contaminants (e.g., BTEX, PAHs) from the surficial fill WBZ to the underlying alluvial WBZ is limited to the northern portion of the Siltronic property, correlating to the area of deeper DNAPL (oil) penetration in the 400 foot wide low area. The hydrocarbon plume has been delineated laterally and vertically along the shoreline, extending across a depth interval of approximately 60 to 150 feet bgs, and laterally along the shoreline from a location north of the common property boundary with Gasco, to a location approximately 375 to 450 feet upriver of the property line. Maximum concentrations of 8,200 ppb benzene and 19,700 ppb naphthalene have been identified in groundwater within the plume at the extreme north corner of the property (86 feet bgs at WS-14).

Available data from in-water borings suggest the upland petroleum hydrocarbon plume is predominantly migrating beneath the river without discharge to shallow sediments, with the extent of the upland benzene and naphthalene plume components having been delineated in the upriver direction.

Directly impacted river sediments at certain areas off-shore of Siltronic are acting as a primary source of dissolved phase naphthalene in the surface sediment porewater. These impacts, derived from placement of contaminated material at the surface, extend downward into the sediments, and based on the profile of decreasing concentrations with depth, may be a source of contamination to deeper groundwater. If groundwater discharging from the upland were the source of the observed porewater concentrations, then concentrations would likely increase, rather than decrease, with depth.

Benzene and naphthalene impacts to groundwater at the southern and western portions of the Siltronic site are primarily limited to the surficial fill WBZ, with impacts extending to the south as a function of a localized southern component of flow toward North Doane Creek and North Doane Lake in this area. A source for the impacts identified at this portion of the site may be the presence of oily zones within the fill, which includes 1.5 million cubic yards of material, including 700,000 cubic yards of dredge material brought from unknown sources. The benzene and naphthalene plumes attenuate laterally at all locations near the southern and western property boundaries, with exception of monitoring well WS-6, located adjacent to the buried pipeline that carries stormwater/North Doane Creek to the Willamette River at City of Portland Outfall 22C. Groundwater seepage into the stormwater pipe, if occurring, could result in discharge to the Willamette River at the Outfall 22C location, which is the subject of a separate, on-going investigation. Outfall 22C is the discharge point for 1,008 acres of drainage that includes several industrial properties, city streets and other transportation right-of-ways.

Cyanide impacts to groundwater are present in the surficial fill WBZ across a majority of the Siltronic property, with the highest concentrations being identified at the central portion of the site, south of the former lowland area (GP-2-01), and extending to the shoreline down-gradient of the former lowland area. Within the underlying alluvial WBZ, concentrations greater than 0.5 ppm have been identified to depths of up to 100 feet bgs, and extending across the northern portion of the Siltronic site. The source(s) for the identified cyanide appear to be related to the surficial fill, but are otherwise not well understood. One potential source for the identified cyanide impacts in groundwater is spent oxide / purifier box wastes that may have been incorporated into fill at the property. However, imported fill is another potential source for the cyanide, especially since the greatest cyanide concentrations (greater than 1,000 ppm) were identified in fill at areas well away from the area where spent oxide was stored, and soils containing the highest cyanide concentrations did not contain field screening evidence of the presence of MGP-related materials (e.g., no wood chips, spent lime, prussian blue coloration, tar or oil).

7.4 Surface and Embankment Soils

Surface soil samples collected along the top of the embankment above the rip-rapped area at Siltronic did not contain total petroleum hydrocarbons or total cyanide, although PAHs and/or SVOCs were identified at low concentrations (less than 2.2 ppm) at the three northernmost locations (e.g., S-1 through S-3). Zinc was identified at the northernmost location (S-1) at a concentration slightly exceeding typical background concentrations. No evidence of overland erosion from the densely vegetated area at the top of the embankment to the heavily rip-rapped embankment, was observed.

Catch basin soils/sludge, which contain soils derived from localized overland erosion, as well as stormwater impacted by routine above-ground operations (e.g., oil and fuel drippage from vehicle parking lot and paved drive areas), contained oil-range petroleum hydrocarbons (9,000 ppm), low levels of total PAHs (2.6 ppm), and low levels of toluene (10 ppm) and cyanide (0.4 ppm). The source for the oil is likely vehicle drippage, while the low level PAH and cyanide concentrations may be indicative of surface soil transport to certain catch basins at the site.

Diesel and oil-range petroleum hydrocarbons, PAHs (91.2 ppm), and cyanide (13,000 ppm) were identified in a sample of embankment soils collected from the only area not completely armored with rip-rap, a location below the Fab 2 outfall. Bank soils are composed of fill. It is not clear if the identified impacts are associated with impacts attributable to the nature of the fill, or if the soils are impacted as a result of historical discharges from the Fab 2 outfall.

Dredging related to bank stabilization activities conducted in 2000 at a location offshore of boring P-4 created an oily sheen, with characterization of the petroleum impacts within the sediments containing oil and diesel-range petroleum hydrocarbons characteristic of a creosote. The location of the identified oily sediments was in proximity to the former ditch that may have received discharges from the former lowland area (1951-1956).

7.5 Subsurface Soils / Non-Aqueous Phase Liquid

Oil and tar, likely attributable to historical MGP waste management practices at the Siltronic site, have been identified near the base of the surficial fill unit and extending into, and beneath, the underlying silt unit within portions of the former 400-foot wide lowland area, where up to 6 feet of oil have accumulated in a well screened to 85 feet bgs, and where oily soils have been observed as deep as 74 feet bgs. Further, DNAPL has been identified in two alluvial WBZ wells screened to 125 feet bgs at a location between the former lowland area and the Willamette River. The area of deep DNAPL migration beneath, and down-gradient of, the former lowland area corresponds to the location of the significant TCE concentrations in groundwater, suggesting the possibility of a cosolvency effect.

No evidence for the migration of oil or tar from the surficial fill to Willamette River sediments exists. Evaluation of shoreline borings with evidence of residual oil or tar in the surficial fill (P-1, P-4, and P-5) does not suggest the product migrated to these locations from upland sources. Instead, it appears the product was either placed on the ground prior to filling (tar at P-1), or that the product was incorporated into the fill during placement (oil at P-4 and P-5).

Oil identified at boring P-7 appears to be the result of spills to the former ground surface from former Western Transportation operations. The low concentrations of PAHs in the oil identified at P-7 (total PAHs are less than 2 percent of the TPH), and the non-detection of cyanide, indicate that the TPH at this location is not MGP-related waste, but is more likely diesel or fuel oil associated with the former Western Transportation fueling operations.

Oil identified in borings installed at the southern and western portion of the Siltronic property, appear to be the result of the incorporation of oily soils into the fill during site filling activities. Data do not indicate DNAPL migration to the underlying alluvial WBZ, or lateral migration of NAPL within the fill at any of these locations.

Direct observation of soil cores from upland and in-water borings indicate the upland DNAPL to be disconnected and separate relative to the shallow oily sediments identified at off-shore locations. Further, due to the depth of the DNAPL near the shoreline; the specific gravity of the DNAPL (greater than 1.0); and the apparent presence of a downward hydraulic gradient beneath the river, the DNAPL does not appear to be a future migration threat with regard to Willamette River sediments.

Oil or tar-bearing sediments off-shore of the northern portion of the Siltronic property are likely the result of historical overflow from the former effluent ponds at the southern end of the current Gasco property via the former ditch located near the current Gasco / Siltronic property boundary (1941 to 1951), and with possible discharges from the former lowland area via the ditch formerly located approximately 400 feet upriver from the property boundary (1951 to 1956).

7.6 Identification of Potential Contaminant Transport Pathways

Based on the preceding, potential contaminant transport pathways between the upland portion of the site and the Willamette River, to be further evaluated as part of an updated source control evaluation document, include the following:

A) Groundwater Pathway

B) Surface Water Runoff Pathway (e.g., Site Outfalls and City of Portland Outfall 22C)

C) Catch-Basin Sediment Transport Pathway

D) Soil Erosion Pathway (unarmored areas of embankment)

7.7 Preliminary Estimation of Additional Data Needs

The following areas have been identified where additional data appear needed to fully support completion of a source control decision at the site with regard to former MGP-related waste management areas.

- Due to the potential for shallow groundwater to discharge to North Doane Creek and/or into the large diameter buried pipe leading to the Willamette River at City of Portland Outfall 22C, additional surface water investigation activities are currently being conducted as per a previously-approved work plan. Results of these investigation activities, as well as source control evaluation related to this feature, will be reported under separate cover.

- The lateral extent of the petroleum hydrocarbon plume beneath the river at the northern portion of the Siltronic property (former lowland area) has not been delineated in the down-gradient direction off-shore to the northeast, and it is not clear what the groundwater discharge/recharge regime may be with regard to this plume further into the main channel. It is anticipated that additional off-shore characterization will be necessary to satisfy these data gaps.

- Additional groundwater quality characterization down-gradient of the former depression/excavation area south of the former lowland area is warranted in order more completely to evaluate the potential for deep impacts (e.g., greater than 100 feet bgs) that may be attributable to this area.

- Additional investigation activities appear warranted with regard to the former spent oxide storage pile area to evaluate whether cyanide impacts from historic spent oxide storage may be contributing to the cyanide concentrations observed in groundwater at the site.

8.0 LIMITATIONS AND SIGNATURES

The information presented in this report was collected, analyzed, and interpreted following the standards of care, skill, and diligence ordinarily provided by a professional in the performance of similar services as of the time the services were performed. This report and the conclusions and/or recommendations contained in it are based solely upon research and/or observations, and physical sampling and analytical activities, if any, that were conducted at the Client's request.

The information presented in this report is based only upon activities witnessed by HAI or its contractors, and/or upon information provided to HAI by the Client and/or its contractors. The analytical data presented in this report, if any, document only the concentrations of the target analytes in the particular sample, and not the property as a whole.

Unless otherwise specified in writing, this report has been prepared solely for the use by the Client and for use only in connection with the evaluation of the subject property. Any other use by the Client or any use by any other person shall be at the user's sole risk, and HAI shall have neither liability nor responsibility with respect to such use.

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10.0 GLOSSARY OF ABBREVIATIONS

AMEC	AMEC Earth & Environment, Inc.
bgs	below existing ground surface
BNSF	Burlington Northern Santa Fe Railroad Company
BTEX	benzene, toluene, ethylbenzene, and xylenes
CDM	Camp Dresser & McKee, Inc.
Cm/sec	centimeters per second
COIs	contaminants of interest
CRBG	Columbia River Basalt Group
DEQ	Oregon Department of Environmental Quality
DNAPL	dense non-aqueous phase liquid
DOE	Washington Department of Ecology
ESL	Environmental Services Laboratory, Inc.
EPA	U.S. Environmental Protection Agency
HAI	Hahn and Associates, Inc.
HCID	hydrocarbon identification
KII	Koppers Industries, Inc.
LNG	liquefied natural gas
LTI	Limno-Tech, Inc.
MFA	Maul Foster & Alongi, Inc.
MGP	manufactured gas plant
Msl	mean sea level
MTBE	methyl-tert-butyl-ethene
NAPL	non-aqueous phase liquid
NPDES	National Pollution Discharge Elimination System
PAHs	polynuclear aromatic hydrocarbons
PCE	tetrachloroethene
PCP	pentachlorophenol
PCST	petroleum-contaminated soil treatment
PDC	Portland Development Commission

PG&C	Portland Gas & Coke
PGE	Portland General Electric
ppb	parts per billion
ppm	parts per million
RI	Remedial Investigation
Siltronic	Siltronic Corporation (formerly Wacker Siltronic)
SVOCs	semi volatile organic compounds
TCE	trichloroethene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
URS	URS Greiner Woodward Clyde, Inc.
UST	underground storage tank
VOCs	volatile organic constituents
WBZ	water-bearing zone